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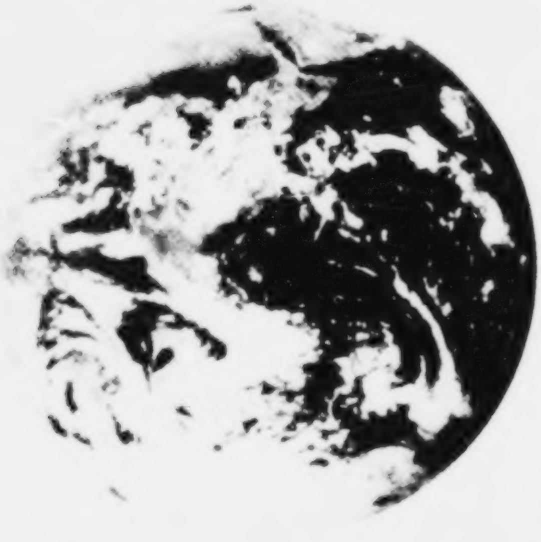

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Proceedings of the International Conference on Pollution Prevention: Clean Technologies and Clean Products

Washington, DC, June 10-13, 1990

Sponsored by the U.S. Environmental Protection Agency:

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RISK REDUCTION ENGINEERING LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
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DISCLAIMER

The following papers have been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication:

Waste Minimization Assessments at Selected DoD Facilities by James S. Bridges

Chrome Recovery Via Adsorptive Filtration by Lisa M. Brown, M.M. Benjamin, and T. Bennett

Evaluation of EPA Waste Minimization Assessment by Mary Ann Curran and K.R. Stone

Waste Reduction Evaluations at the Philadelphia Naval Shipyard and Fort Riley, Kansas by George C. Cushnie, Jr.

Reclaiming Fiber from Newsprint by Dry Methods by Dennis E. Gunderson, C.T. Scott, R.L. Gleisner, and T.M. Harten

Managing a Hazardous Waste Minimization Investigation by Garry O. Kosteck and S.P. Sobol

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Integrated Permits and Multi-media Pollution Prevention by Dr. Mahesh K. Podar

Prototype Evaluation Initiatives in a New Jersey Vehicle Maintenance and Repair Facility by Paul M. Randall

All other papers published in this Proceedings describe work that was not funded by the U.S. Environmental Protection Agency and therefore do not necessarily reflect the views of the Agency and no official endorsement should be inferred.

FOREWORD

Today's rapidly developing and changing technologies and industrial products and practices frequently carry with them the increased generation of materials that, if improperly dealt with, can threaten both public health and the environment. The U.S. Environmental Protection Agency is charged by Congress with protecting the Nation's land, air, and water resources. Under a mandate of national environmental laws, the Agency strives to formulate and implement actions leading to a compatible balance between human activities and the ability of natural systems to support and nurture life. These laws direct the EPA to perform research to define our environmental problems, measure the impacts, and search for solutions.

The Risk Reduction Engineering Laboratory is responsible for planning, implementing, and managing research, development, and demonstration programs. These provide an authoritative defensible engineering basis in support of the policies, programs, and regulations of the EPA with respect to drinking water, wastewater, pesticides, toxic substances, solid and hazardous wastes, and Superfund-related activities. This publication is one of the products of that research and provides a vital communication link between researchers and users.

These Proceedings from the first biennial International Conference on Pollution Prevention: Clean Technologies and Clean Products provide the results of projects recently completed by RREL and current information on active projects. These Proceedings also provide information on pollution prevention activities currently underway in the private sector, and in nations other than the United States.

The Risk Reduction Engineering Laboratory and the Pollution Prevention Office will continue to sponsor this conference in order to assure that results of research efforts and policy decisions are rapidly transmitted between government and industry, and between national governments, and among those interested in the area of pollution prevention. The 1990 Conference attracted 1,007 attendees from industry, government, and academia, including participants from 43 countries.

E. Timothy Oppelt, Director
Risk Reduction Engineering Laboratory

ABSTRACT

The International Conference on Pollution Prevention: Clean Technologies and Clean Products, was held in Washington, DC, June 10-13, 1990. With support from the Department of Defense, the Department of Energy, and the International Association for Clean Technology, this conference explored the innovative technologies and socio-economic issues arising in the field of pollution prevention. These Proceedings include papers and transcripts of most of the presentations made during the three-day conference.

TABLE OF CONTENTS

Page

Towards Implementation of Environmental Policies
by Dr. Hanns A. Abele 1-8

Systematic Process Design and Analysis for Waste Minimization
by Dr. Robert C. Ahlert 9-18

Cleaner Technologies in the Tanning Industry
by Dr. Ken Alexander and V. Donohue 19-31

Waste Minimization - Approaches and Techniques
by Dr. Raymond J. Avendt 32-40

The Army's Hazardous Waste Minimization Program
by Robert P. Bartell, J.L. Mahannah, and M.J. Dette 41-47

Corporate Transition to Multi-Media Waste Reduction Measuring Waste Reduction Progress
by David M. Benforado 48-56

Creating the Conditions for Sustainable Development: Programmes and Instruments for Pollution Prevention
by Dr. Robin Bidwell 57-66

Technical Assistance Tools and Approaches Waste Reduction Incentives and Barriers: The Florida Experience
by William W. Bilkovich 67-72

Underground Coal Gasification: Groundwater Contamination Can Be Prevented
by John E. Boysen, J.R. Covell, J.M. Evans, and C.R. Schmit 73-85

Business to Business Networking - A Cycle or Short Circuit?
by J.B. Brand, Jr 86-88

Waste Minimization Assessments at Selected DoD Facilities
by James S. Bridges 89-99

Chrome Recovery Via Adsorptive Filtration
by Lisa M. Brown, M.M. Benjamin, and T. Bennett 100-110

The State of Ohio Pollution Prevention Technology Transfer Program
by Orville S. Burch and P.S. Rafferty 111-117

The Use of Economic Incentives for the Introduction and Adaptation of Clean Technologies
by Dr. Demetrios G. Cacnis 118-129

Page

Pollution Prevention Through Waste Reduction in Florida
by Janeth A. Campbell and R. Wilkins....130-139

A Ride Through Space - With Care and Concern
by William J. Carroll....140-143

Organizational Behavior as a Key Element in Waste Management Decision Making
by Peter B. Cebon....144-153

An Approach to Hazardous Waste Reduction and Pollution Control in Thailand's Upcoming Terphthalic Acid Industry
by Dr. Ramendra N. Chakrabarty....154-163

Address Before the EPA/IACT International Conference on Pollution Prevention
by Dr. Barry Commoner....164-174

Information Networking for Pollution Prevention
by Daniel E. Cooper....175-177

Facility-Specific Waste Minimization Plans at Westinghouse Hanford Company
by P.A. (Penny) Craig....178-187

European Experiences in Stimulating Cleaner Technologies
by Drs. J. Cramer and F. van den Akker....188-195

Evaluation of EPA Waste Minimization Assessment
by Mary Ann Curran and K.R. Stone....196-203

Waste Reduction Evaluations at the Philadelphia Naval Shipyard and Fort Riley, Kansas
by George C. Cushnie, Jr....204-217

Securing Safe Substitutes: Policy Measures to Promote Safe Chemical Substitutes
by Gary A. Davis....218-227

Open-Gradient Magnetic Separation for Physical Coal Cleaning: Results for Pittsburgh #8 and Upper Freeport Coals
by Richard D. Doctor and C.D. Livengood....228-235

An International Environmental Conscience and America's Role
by Donald J. Ehreth....236-245

Strategies for Source Reduction
by Christine A. Ervin....246-253

Page

Multimedia Local Government Pollution Prevention Programs
by Anthony Eulo....254-262

Materials Substitution at the Rocky Flats Plant
by Ann C. Ficklin and G.L. Hickle....263-273

Moving Beyond the Rhetoric: Challenges for the 1990s
by Kathryn S. Fuller....274-283

Regulatory Impediments to the Reclamation and Reuse of Spent Potliner from Primary Aluminum Production
by Dr. Jack H. Goldman and J.S. Holik....284-293

Reclaiming Fiber from Newsprint by Dry Methods
by Dennis E. Gunderson, C.T. Scott, R.L. Gleisner, and T.M. Harten....294-306

DoD Oil and Hazardous Substances Pollution Prevention Program
by Dr. Brian P.J. Higgins....307-312

DLA Comprehensive Hazardous Materials Management Program
by W. Joseph Hoenscheid and W. Beddoes....313-322

Economic Incentives for Recycling: An Examination of U.S. Environmental Policy for Financing Recycling Facilities
by Scott L. Hoffman and M.H. Levin....323-331

Societal Eco-Sustainability: The Opportunities and Responsibilities for Colleges and Universities
by Dr. Donald Huisingh....332-341

The Legal Basis for Waste Avoidance and Waste Utilization in the Federal Republic of Germany
by Will A. Irwin....342-345

Segregation for Recycle and Reuse of Hazardous Chemical Material at Los Alamos National Laboratory
by Patrick Josey....346-350

Waste Minimization Strategy Flexible Polyurethane Foam Manufacture
by Dr. Clifford M. Kaufman and M.R. Overcash....351-360

Waste Minimization Assessment Centers
by F. William Kirsch and G.P. Looby....361-371

Liability and Benefit Sharing for Joint Production Activities Involving Risks
by Dr. Paul R. Kleindorfer and A. Watabe....372-379

Page

Managing a Hazardous Waste Minimization Investigation
by Garry O. Kosteck and S.P. Sobol....................................380-386

Implementing Incentives: Experience and Expectations
by Michael H. Levin..387-396

IGT Bioprocess Technology Development Efforts for the Production of Clean Fuels
by Andrea Maka and V.J. Srivastava....................................397-404

Energy Resource vs. Buried Waste: Spent Potliner in a Cement Kiln
by Elbert G. Massad..405-407

The Enlarged European Environmental Market: Impediments and Opportunities
by Jan C. McAlpine...408-412

U.S. Air Force Hazardous Materials Management Initiatives
by Brian D. McCarty and J.J. Short.....................................413-422

Illinois/EPA WRITE Program
by Dr. Gary D. Miller, W.L. Tancig, and P.M. Randall...................423-433

Pollution Prevention in the Electric Utility Industry
by Michael J. Miller...434-444

Coal Refuse To Energy
by Dr. Ronald D. Neufeld...445-453

Sandia's Search for Environmentally Sound Cleaning Processes for the Manufacture of Electronic Assemblies and Precision Machined Parts
by Michael C. Oborny, M.G. Benkovich, J.V. Dichiaro, D.R. Frear,
E.P. Lopez, D.R. Ostheim, R.F. Salerno, and R. Waterbury, Jr.........454-464

Recovering Value from Process Wastes
by Dr. Frank T. Osborne, C.T. Chi, and J.H. Lester.....................465-474

Design for the Entire Life Cycle: A New Paradigm?
by Dr. Chuck Overby..475-482

Waste Reduction at a Printed Circuit Board Manufacturing Facility Using Modified Rinsing Technologies
by Paul Pagel..483-492

Department of Defense Pollution Prevention Initiatives
by William H. Parker, III..493-499

Crop and Pasture Land Conversion Opportunities for Mitigating Global Warming
by Peter J. Parks..500-509

Page

Toxic Waste Trade in Africa and the Caribbean: From Regulation to Pollution Prevention
by Hugh G. Pilgrim....510-519

Integrated Permits and Multi-media Pollution Prevention
by Dr. Mahesh K. Podar....520-527

Pollution Prevention in the 21st Century: Lessons from Geneva
by Dr. Arthur H. Purcell....528-534

Prototype Evaluation Initiatives in a New Jersey Vehicle Maintenance and Repair Facility
by Paul M. Randall....535-544

Short-Rotation Woody Crop Opportunities to Mitigate Carbon Dioxide Buildup
by J. Warren Ranney (speaker), R.L. Graham, A.F. Turhollow, and L.L. Wright....545-557

Corporate Transition to Multimedia Waste Reduction
by Denny B. Redington....558-562

Pesticide Application Equipment Rinse Water Recycling
by Darryl Rester....563-572

Pollution Prevention in Textile Wet Processing - An Approach and Case Studies
by Stephanie Richardson....573-581

The Business Council of Alabama Waste Minimization Initiative
by David L. Roberson....582-584

Wastewater Recycle Facility at IBM East Fishkill
by James G. Sales....585-593

State Mandated Pollution Prevention - Legislative and Regulatory Initiatives to Compel Reduction of Use of Hazardous Chemicals
by John M. Scagnelli....594-603

The Linear Tubular Reactor - A New Process for Reclaiming Used Oils and Decontaminating Other Hazardous Wastes Via Molecular Threshold Distillation and Molecular Condensation
by Dr. Christian Schoen....604-612

Approaches to Reducing Environmental Risk Through Pollution Prevention
by John J. Segna and R.K. Raghavan....613-623

Page

Educational Aspects of Multimedia Pollution Prevention
by Dr. Thomas T. Shen....................................624-632

Industrialization, Development and the Environmental Crisis in Developing Economies of the Caribbean Basin Region
by Dr. Winston H.E. Suite................................633-642

An Innovative Graduate Thesis: A Team Evaluation of Used Oil End Uses
by Cynthia J. Talbot, J.P. Byrne, C.A. Cody, P.J. Doyle, A.H. Mayor, A.M. Reid, and S.K. Rosner....................................643-651

Presentation at the Opening Plenary
By Dr. A. Tchecknavorian-Asenbauer.......................652-655

Clean Production: From Concept to International Campaign Through Networking
by Beverley Thorpe and L.J. Bunin........................656-664

Recovery of Chromium from Tannery Wastewaters
by Dr. Dimitrios Tsotsos.................................665-675

Waste Prevention Strategies in the Flemish Region of Belgium
by P. Van Acker..676-685

Water Pollution Prevention in The Netherlands
by Dr. Frans A.N. van Baardwijk and H.B. Pols............686-695

New Directions in Waste Minimization Technologies: Water Conservation Offers Multi-Faceted Benefits
by Amy Vickers...696-702

Process Options for Waste Minimization and Metal Recovery for the Metal Finishing Industries
by Dr. Clifford W. Walton, A.C. Hillier, and G.L. Poppe..........703-712

CFC Pollution: Repairing the Ozone Hole Through Municipal Legislation
by Dr. Frances E. Winslow................................713-719

A Novel Low-Pollution Approach for the Manufacture of Bleached Hardwood Pulp
by Alfred Wong and J. Tichy..............................720-729

Towards the Promotion and Implementation of Pollution Prevention and Clean Technology in Developing Countries: The Case of Ghana
by Dr. Gregory E. Yawson.................................730-737

Hazardous Waste Minimization: Making It Happen
by Paul J. Yaroschak.....................................738-747

TOWARDS IMPLEMENTATION OF ENVIRONMENTAL POLICIES

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ABSTRACT

For decades it has been known that environmental problems constitute a distortion in the allocation of resources. How to deal with these distortions and to improve the working of an economy has been controversial. Recent developments in economic theory especially in the fields of bargaining, mechanism design, and economics of information offer hope to find solution for the urgent problems which are incentive compatible and rely on a sound decision theoretic framework.

The paper surveys recent results and discusses their chances for policy implementation. Both views from the policymaker and from the decision making firm are covered. This allows to deal with the problem of social costs and external effects using the concepts and ideas of results on strategic behavior.

Because of the complexity of the issues and the lack of generally working mechanism a pragmatic approach is favoured.

INTRODUCTION AND SUMMARY

For decades it has been known that environmental problems constitute a distortion of the allocation of resources. That means that the welfare of economic agents is not at the best possible level. Viewed from an efficiency criterion either more inputs are used than necessary or output is not at the achievable level or both. Economics has been traditionally interested in finding the reasons for such deficiencies of economic processes. Basically the main line of research was to identify welfare losses and design policies to correct inefficiencies in allocations of resources.

Within a Walrasian general equilibrium framework it has been relatively easy to establish the reason for allocative distortions. Since the main results of general equilibrium theory establish the existence of a general equilibrium in a competitive market framework it is clear that any failure of markets or any violation of the competitive structure (assumptions) may imply some suboptimality. The competitive general equilibrium can be shown to be efficient or optimal with respect of the Pareto criterion. The conclusion of the long debate has been that market failures and externalities give rise to allocative deficiencies. Such externalities can be very general. It suffices that consumption of an individual is dependent on the consumption of another individual like behavior according to "keep up with Joneses".

Environmental problems like pollution or hazardous waste are therefore theoretically speaking simple questions of the effect of externalities on the efficiency of an allocation. They constitute no extraordinary difficulty at least at first reflection. Since Pigou suggested a tax/subsidy solution to deal with such deviations from Pareto optimality in the 1920's there has been an ongoing debate. The opponents of Pigou's position argued that it is impossible for government to design the correct intervention mechanism because it lacks the necessary information. Furthermore one can construct examples where the production functions of the firms involved are such that government intervention deteriorates the situation instead of improving it.

The other prominent strand of ideas seeks a solution of the problem in supplementing the seemingly not correctly functioning market with a negotiating structure. Coase[1] is regarded as having formulated the central ideas in his famous paper on social cost. It holds that people being unconstrained to bargain will reach an efficient economic solution of an externality problem.

However, despite this appealing result there are fundamental doubts about its relevance. The basic assumption of the existence of a costless bargaining and enforcement mechanism as well as perfect information of the parties involved limit the scope of the applicability of the Coase "theorem"...Whether it is probable that these conditions are fulfilled is rather questionable. Sometimes the discussion rests more on ideology than analytical arguments.

Both lines of theoretical reasoning, a more centralized solution relying on government action and a decentralized "market" oriented bargaining approach, cannot provide solutions for the problem of environmental externalities in general. The problem is far more complex than it seemed to be some decades ago.

On the other hand the pressure to provide satisfactory solutions has increased dramatically. Continuous population growth and increased use of industrial production techniques create enormous amounts of pollution and environmental deterioration. Public awareness has responded to the challenge. High visibility of accidents – Seveso, Bhopal, Tschernobyl, Alaska – forested public understanding of environmental hazards and their possible long run effects. People learned that there are limits of ecosystems which imply that it is possible to cause destabilization of the global system risking the extinction of mankind.

Needless to say this situation poses a great dilemma. While the risks may need immediate action the theoretical foundations are in dispute not only in science like the discussion of the greenhouse effect but also in social sciences and economics leading to a deadlock as far as the design of effective policies is concerned. If the environmental problems transgress national borders as they do in most cases a global response is necessary. This makes solutions not easier.

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[1] RONALD CASE, The Problem of Social Cost. Journal of Law and Economics, 1960, I, 1-44

INSTITUTIONS AND POLICIES: THEORETICAL REMARKS

In order to measure the effects of externatilities and policies or institutional settings to remedy undesirable outcomes it is necessary to have a benchmark economy. As optimality criterion Pareto-efficiency is used. That means it is impossible to find another outcome of the system improving at least one agent without making another one worse off.

If for some reason assumptions of this model of a market economy are violated, optimality in the sense of Pareto can be precluded. One such assumption is independence of the economic agents. A factory may emit smoke and thus influence the production of a neighboring laundry. The production of the latter is thus dependent on the output or the production of the first. Similarly, interdependency may arise in consumption. Another formulation of the same effect is to diagnose a discrepancy of social and private costs. The polluting firm does not calculate the costs of avoiding the smoke or additional cleaning, because there is no necessity for it. However, if there is an agency levying a pollution tax on the emitting firm and paying a subsidy to the laundry for the damages, it was thought to be possible to internalize the social costs and achieve again an optimal outcome. This was Pigou's approach.

In contrast Coase argued that the laundry owns a property right to clean air and therefore can hold the smoke emitting factory responsible and liable. By negotiations the agents involved will resolve the suboptimality. Smoke will be emitted only if it is profitable for the firm to do so after compensating the laundry for damages. Hence efficiency is again secured but without government intervention.

The discussion of the two competing approaches as well as the analysis why they fail in certain circumstances and last not least a better understanding of the assumptions on which they rely contributed a lot to the knowledge of the functioning of an economy. Despite the prominent role of markets in discussions about economics (and ideology) a lot of important features of exchange, interaction and coordination of decisions has been left in rather vague formulations resting on attractive but unproven ideas. Research faced this challenge and has tried to remedy these deficiencies.

DESIGNING REGULATORY POLICIES

Critics of the Pigouvian taxes/subsidies scheme were quick to point out that such a policy cannot solve the problem of improving the welfare characteristics of a distorted allocation simply because the government has not the necessary knowledge to design the policy. Even if it would be possible to collect the information it would be far to costly to do so. Thus the overall result would be an inferior outcome.

In response to the critique there are numerous studies of the influence of limited information on the possibility of regulation.[2] To illustrate the conceptual problems, assume that the regulator does not know the cost function of the firm. It can be either of two, a low cost or a high cost function. Can the regulator decide on an optimal policy? In general when an important characteristic of one party is not observed by the other, adverse selection occurs. Informational asymmetrics and uncertainties add strategic elements to the decisions of the parties. It is not the same whether the regulating agency has to commit itself to a specific policy before the firm acts or only simultaneous actions are allowed. The firm may try to get higher profits by misrepresenting its situation which can be countered by providing incentives to reveal the true situation. Monitoring may improve the informational position of a regulator. But even monitoring may be imperfect and for sure it is not costless. If the firm, say, may take actions which cannot be monitored and controlled by the regulator, the situation is complicated again. Moral hazard is possible in several variants. It may appear as a second incentive problem in addition to adverse selection. This has to be accounted for in the design of regulatory policies. In general a policy which aims at correcting one problem will not be useful in the other situation, and policies in the simultaneous presence of both problems again need to be rather different.

Time and dynamics represent another difficulty. If certain standards are set and the firm succeeds in meeting them and as a consequence the standards are raised, the firm will no longer have incentives to comply with the regulating efforts (ratcheting). Thus multiperiod regulatory policies need to be considered with respect of commitment and credibility.

---

[2] DAVID BESANKO, DAVID E.M. SAPPINGTON, Designing Regulatory Policy with Limited Information. Harwood Academic Publishers: Chury e.a. 1987.

Very often multiple regulators as well as multiple firms characterize the problem. Sometimes the regulated firms have bargaining power to influence the goals of the regulator(s). In any case the complexity of the problems for the design of regulatory policies necessitate careful analysis and mechanism design.

DECENTRALIZED BARGAINING

Can negotiations repair externalities? A closer scrutiny of the Coase "theorem" made it clear that a crucial assumption for this proposition is the absence of any private information. Based on the formulation of cooperative game theory it is important for the result that every player knows every other's payoff (utility, profit).[3] In case of private information, property rights and bargaining will not be a fully efficient remedy.[4] The distribution of property rights influences the outcome together with the specific bargaining method used. Even in comparison to a bureaucratic institution the result may be more or less efficient.[5]

Intuitively a large number of participants that is a large number of agents suffering from environmental damages seem to make it more difficult to achieve an efficient outcome by negotiations. Rob showed in a recent contribution that it is very unlikely to reach efficient outcomes in the case of many participants.[6] Although it is socially beneficial, a firm not knowing the true damages its operation cause will abstain from operation since the stated damages supersede its profits because the participants tend to inflate their compensation demands. This adds another caveat to the general usefulness of the properly rights and negotiation approach.

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[3] KENNETH J. ARROW, The Property Rights Doctrine and Demand Revolution under Incomplete Information. In: M.J. BOSKIN (ed.), Economics and Human Welfare. Essays in Honor of Tibor Scitovsky. Academic Press, New York e.a. 1979, 23-39.

[4] WILLIAM SAMUELSON, A Comment on the Coase Theorem. In ALVIN E. ROTH (ed.), Game Theoretic Models of Bargaining. Cambridge University Press: Cambridge e.a., 1985, 321-339.

[5] JOSEPH FARRELL, Information and the Coase Theorem. Economic Perspectives, 1(2), Fall 1987, 113-129.

[6] RAEFAEL ROB, Pollution Claim Settlements and Private Information. Journal of Economic Theory, 47 (1989), 307-333.

The increased effort of research on the subject of the allocation of resources under uncertainty has led to a better understanding in dealing with externalities. A general picture emerges which can help to guide decisions for environmental policies. Although it seems to be that there is no general solution possible, neither centralized nor individualistic, economic theory has advanced a lot and produced suggestions for solutions in specific circumstances. It is reasonable to proceed by solving on a case by case approach.

INSTITUTIONS AND POLICIES: PRAGMATIC OBSERVATIONS

Given the complexities of environmental problems and the analog difficulties of their theoretical handling it is reasonable to try to divide the questions in smaller parts and deal with these peces.

With respect to the time dimension it is possible to distinguish

(i) old problems, e.g. abandoned landfills,

(ii) current problems, e.g. pollution and waste being created at the moment,

(iii) future prevention of environmental problems, e.g. shift to clean technologies.

(i) One may feel that an environmental cleanup should be based on the principle of strict retroactive liability. This turns out to be almost impossible. Very rarely all the firms are still in existence having dumped their waste on a site which is now regarded as a dangerous place. At the time of the dumping it was almost always perfectly legal to do so. The amounts of the claims would often force the firms into bankruptcy. Therefore, they are ready to fight any order to pay for the clean up as long as possible retarding any action to reduce environmental dangers. Finally, they may argue that their customers profited from their dumping activity because they paid lower prices than they would have done otherwise in the past.[7] Weighing all the arguments and the experience of the Superfund program in the USA it is clear that it is necessary in order to improve environmental quality for the public to pick up the lion's share of the costs together with private business.

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[7] MAURICE R. GREENBERG, Financing the Clean-up of Hazardous Waste: The National Environmental Trust Fund. The Geneva Papers on Risk and Insurance, 14 (51, April 1989), 207-212.

(ii) To deal with present problems is the most difficult part of the questions. It is necessary to use all the results of theoretical research and invest in technological developments. A risk averting strategy can be to avoid hazardous waste as much as possible. Incentives may guide producers to think about the life cycle of their products and help by shifting to other components or process to reduce environmental problems.

(iii) For the future the core of an environmental policy has to be to avoid known hazardous waste and pollution. Again a shift to clean technologies is of central strategic importance.

In the international context it may be advantageous for all countries if the wealthier nations help the developing countries to avoid errors they themselves made with respect to a clean environment. The establishment of an international fund or in addition an agency may be helpful to stimulate efforts to improve environmental quality and develop policies in an international context.

SYSTEMATIC PROCESS DESIGN AND ANALYSIS FOR WASTE MINIMIZATION

by: Robert C. Ahlert, PhD, PE, Dist. Professor
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ABSTRACT

The concept of 'audit' has become a cornerstone of policies and programs dedicated to source reduction as the primary mechanism for hazardous waste minimization. Audits are variously targeted at process units, single processes or systems of processes [manufacturing plants]. In parallel, audits have been described in terms of individual chemicals species, process streams and overall differentials in plant inputs and outputs [raw materials and products]. These considerations must be viewed as environmental medium and waste state dependent, i.e., volatile matter [air], liquid waste [water] and/or solid waste [soil]; note, these relationships are intentionally simplistic.

Within the intended context of an audit, it is the fundamental mass balance of Chemical Engineering process design and analysis. The mass balance or audit is characterized by a point in three-dimensional process space. Process space, from either a design, operations or regulatory perspective, is nearly continuous in scale and fineness of chemical identification and relatively discrete in physical state. Scale, chemical detail and waste state(s) must be specified before the audit is undertaken. If economic factors are important, an energy balance must be included, under the same prespecified conditions.

A hypothesis has been examined critically: waste management is a basic element of any process design. A process design or redesign is to incorporate alternative materials and new technologies that permit elimination of hazardous waste at the point of origin. Numerous case studies have demonstrated that this philosophy does not differ substantially from the design goals of high yield and product purity/performance, with maximum net profit. The dominant conclusion from this review is that mass balances must be carried out at appropriate scales and detail; one or more environmental media may be involved. Whether for design, operational control or performance monitoring, mass balances must be matched with process characteristics. Detailed chemical compositions are not useful or attainable in petroleum refining or drug manufacturing.

INTRODUCTION

During the decades of the 70s and 80s, the public mounted increased pressures to stop pollution, enact legislation and implement technologies to achieve and maintain a clean environment. Congress responded with a broad array of statutes addressing clean air, soil and water, hazardous wastes and toxic substances. These Acts have seemed to some to be a patch-work quilt of regulation and a sometimes contradictory maze of voluntary compliance and mandatory requirements with enforcement orientation. Emotions have run high. Society, in general, has been outraged by environmental insults typified by Silent Spring and Love Canal.

Immediate expenditures were once the governing factor in selection of treatment technology by industry, municipalities and regulatory agencies. However, in many cases, long-term operation, maintenance and monitoring costs are significant in comparison with short-term costs of 'permanent' containment, detoxification or destruction. The concept of long-term (perhaps perpetual) care can extend to periods of 20 to 200 years. Total costs are very difficult to estimate and even more difficult to put into the context of changing national economy. True cost must include potential liabilities and future mandates for waste recovery and additional treatment based on more stringent environmental standards. National policy has shifted cost to only one of several factors that must be considered in waste management and site remediation assessments under the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA).

Land-based containment remedies have been sharply criticized. The United States Environmental Protection Agency (EPA) has estimated that most land disposal sites will fail within a limited number of years of operation. The House Committee on Energy and Commerce published a report in 1985 indicating that 75% of all permitted land disposal facilities are out of compliance, have leaked or operate under undefined conditions. USEPA land bans issued over the last two years have confronted this problem directly.

Avoidance or minimization of waste generation reduces the problem of disposal. A major factor in modern process design, process and product acceptability, and process economics is waste generation and disposal. If a process can be redesigned or a new process developed to eliminate waste sources, by selection of alternate raw materials and/or revised reaction pathways, it gains economic and operational advantages. Waste minimization through operations controls, personnel training, maintenance scheduling and adjustments to process operating conditions must be evaluated. Recycle and reuse, with or without purification or complete recovery, are methods well suited to solvents, reaction baths, process intermediates and co-products. If waste isn't generated, in an absolute sense, there is no need for waste disposal.

The Resource Conservation and Recovery Act of 1976 (RCRA) states the national policy that "generation of hazardous waste is to be reduced or eliminated". California has taken the position that "waste reduction as opposed to waste management is the ....preferred strategy".

REGULATORY PHILOSOPHY

Congress began enacting environmental legislation in the early 1950s. The legislative history and judicial/technical interpretations have been summarized by Majumdar [1]. Initially, the approach was single receptor oriented, as exemplified by the Clean Air Act of 1970 (CAA) and the Clean Water Act of 1972 (CWA). Subsequently, the approach became multi-media and was changed to focus on hazardous and toxic substances. The Toxic Substance Control Act of 1976 (TOSCA) regulated anticipated and actual manufacturing, processing and use of certain classes of these compounds. In parallel, RCRA defines a solid waste to be hazardous if it has any of the following characteristics: ignitability, corrosivity, reactivity or toxicity. RCRA specifies maximum concentrations for eight metals and six pesticides, in extracts derived by the EPTOX procedure; EPTOX has been supplanted by TCLP extraction. Under RCRA, EPA has established three hazardous waste lists: wastes from nonspecific sources [spent nonhalogenated solvents], wastes from specific sources [sludge and sediment from treatment of wood preserving process wastewaters], and discarded commercial chemical products and all off-specification chemicals, containers and spill residues. Facilities and equipment for transport, storage and disposal (TSD) of hazardous wastes are regulated under RCRA, also.

EPA rulemaking and proposed rulemaking are published in the Federal Register (FR); the FR is published daily. Annually, promulgated final regulations are codified in the Code of Federal Regulations (CFR) [2]. Periodically, changes in the Code can be checked in the Supplement to the Register [3]; the Supplement identifies where changes are located in the FR.

RCRA was strengthened by the Hazardous and Solid Waste Amendments of 1984 (HSWA). Whereas TOSCA and RCRA were intended to regulate uses, inventories and disposal of hazardous and toxic chemicals, CERCLA, otherwise termed Superfund, was aimed at correcting poor disposal practices of the past and the numerous unclosed or uncontained sites that resulted. The Superfund Amendments and Reauthorization Act of 1986 (SARA) significantly extended the scope of CERCLA/Superfund. Requirments for emergency planning and a mandate for community right-to-know were added. Title III of SARA is tied to Hazard Communications Standards (HCSs) of the Occupational Safety and Health Administration (OSHA). Workers must be informed of the hazardous properties of chemical substances, whether the employer is a manufacturing enterprise or not.

The Williams-Steiger Act of 1970 established OSHA [4]; the intent of Congress was to "assure as far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources". Under this Act, designers are responsible for inherently safe processes and plants. The employer is responsible for all aspects of operational safety. Final standards set by OSHA are given in CFR [5]. As with EPA, proposed and interim standards appear in the FR and changes to CFR are summarized in the Supplement to FR [3]. To assist the designer in efforts to assure safe systems and operations, a number of organizations have developed safety guidelines and recommendations for design criteria. These include: American Institute of Chemical Engineers (Dow Chemical Process Safety Guide), National Fire Protection Association and the Manufacturing Chemists Association. Burklin lists and discusses these and other organizations and their resources [6, 7 & 8]. The roles of OSHA and EPA are complementary; as an example, EPA issued standards for storage of petroleum liquids in vessels larger than 245 m^3 [9]. Chemical process safety and environmental compatibility are closely coupled.

DESIGN PHILOSOPHY

GOALS & IMPACTS

The traditional goals of chemical process design are maximum net profit and rapid return on investment. These goals are furthered by high process yield and production of marketable materials of appropriate quality. Design and operational issues that have confronted owners/managers include:

- Labor relations & safety
- Public image (consumer products)
- Insurance
- Liabilities
- Waste disposal

Industry has been mindful of the cost of accidents and the short- and long-term effects of poor safety and operator training. Anetti calculated that the cost to a chemical company (DuPont) for the loss a single work day due to injury exceeds $16,000 [10]. With respect to waste disposal, a Report prepared for the National Research Council by a select Committee on Institutional Considerations in Reducing the Generation of Hazardous Waste concludes that "waste treatment and disposal must be properly priced" [11]. This is a critical design issue. Waste management must be allocated by product and process, not on a plant wide basis.

Process design in the 90s is driven by regulation. The major goals have been expanded to include compliance. Community and worker right-to-know, safety, environmental compatibility of processes and products, plans for emergency response, source reduction, product liability and economic and criminal penalties have significant associated costs. Thus, design factors have changed intent and technical substance; a suitable set of design considerations includes:

- High yield with recycle of secondary reaction products or unreacted raw materials
- Product quality and consumer safety
- Minimum discharge to the environment
- Worker and community education (Right-to-Know)

- Emergency planning (SARA)
- Hazardous waste detoxification or destruction (RCRA)
- Sins of the past to be avoided (PRPs under CERCLA-NPL)
- NIMBY

PROCESS EVALUATION

The fundamental reference for process design and analysis is the Basis of the Calculation or Mass Balance(s). This basis can be a point, i.e., vent or transfer station, a process unit, i.e., reactor or separation device, a process train or an entire facility. Further, a mass balance can be developed around a single chemical species or a complex of species, i.e., light naphtha cut from a petroleum crude or still bottoms. Levels of pure species balances can and should vary from gross to trace in sensitivity; production of sulfuric acid differs in this regard from pharmaceutical manufacturing. The statement of a Basis is essential, whether the issue is optimum process design or regulatory assessment.

Sheevers and Muir demonstrated the use of fragmented regulatory data to draw a nominal mass balance around an entire facility for a single, gross chemical constituent, i.e., toluene [12]. Their model is far too simplistic to fulfill a need for process performance evaluation. In addition, this study reflects the difficulty of using regulatory reporting as a means of performance evaluation and source assessment. The facility selected for the illustration operates in the batch mode and is highly time variant; a large number of processes utilize many raw materials, generate many products and numerous waste streams. The plant has an equally large numbers of co-products, by-products and intermediates.

How successful was the evaluation of toluene consumption and releases by the target facility? Over 95% is consumed on site and none is present in products, e.g., toluene is consumed in hydrodealkylation and none is present in product. The authors estimated that <1% of the toluene input is released to air and <2% is discharged directly or indirectly in wastewater. A RCRA Manifest indicates <0.05% of the feed is transported off-site as a hazardous waste. Based on a regulatory foundation, the Basis is inconsistent and the mass balance is not complete.

TRADITIONAL DESIGNS

The process for manufacture of biodegradable detergent, i.e., sodium dodecylbenzene sulfonate (DBS), is an excellent example of opportunity for waste reduction. Flow diagrams, economics and nominal mass balances are found in the popular design text of Peters and Timmerhaus [13]. Alkylation is followed by sulfonation and neutralization. Alkylation reactor product is fractionated; unreacted benzene and dodecane are recycled. Aluminum chloride sludge is wasted from the reactor after settling and heavy ends are wasted from a distillation sequence. Spent acid is wasted from the sulfonation reactor. Water is separated in a spray drying step. In all, two pounds of waste are generated for each pound of dry product. As little as one pound of benzene in dryer overhead would yield an aqueous waste stream at a concentration of about 20 ppm. This is unacceptable for direct discharge; the pretreatment standard for benzene is 134 ppb (any one day) [14]. Spent acid, heavy ends and sludge are suspect hazardous wastes under RCRA. Redesign to minimize waste is appropriate.

Production of polystyrene (PS) is used as the basic illustration for process design and economic evaluation by Baalsel [15]. Polymerization is carried out in aqueous suspension, with buffer, free radical source and surfactant. Polymer is washed with dilute hydrochloric acid, centrifuged, rinsed and dried. Wastewater is generated by centrifuging; additional water is generated in the drying step. In total, 5.5 pounds of wastewater are generated for each pound of polymer. Wastewater contains about 0.6% suspended and dissolved solids. Also, about 1.5% of the polymer stream is off-specification. Treatment and disposal represent significant cost factors; however, this issue is not addressed. Process water consumption is a major target in both the DBS and PS processes.

APPROACHES TO WASTE MANAGEMENT

ALTERNATIVES

Disposal Options include:

- On-site destruction
- Recycle - Reuse
- Pretreatment & discharge to a POTW
- Pretreatment & manifest to a RCRA-TSD
- Off-site treatment

Source Reduction and/or Elimination can utilize:

- Alternate process technology
- Substitute solvent or reactant(s)

During the decade of the 80s, disposal options were narrowed considerably. Under Section 308 of CWA, as modified by the Consent Decree of 1976 (NRDC vs Train) and several subsequent court orders, EPA promulgated effluent limitations, guidelines and standards for several industrial categories. Limits on discharges to surface waters and Publically Owned Treatment Works (POTWs) have been strictly defined. Regulations are based on "best practicable control technology currently available" (BPT) and "best practicable technology economically achievable" (BAT). Hund et al summarize pretreatment standards for new and existing point sources in the Organic Chemicals, Plastics and Synthetic Fibers (OCPSF) Point Source Category [14]. This report contains the data on which 48FR11828 (03/21/83), 50FR29071 (07/17/85), 50FR41528 (10/11/85) and

51FR44082 (12/08/86) are based. The OCPSF industry includes nearly 1,000 plants, of which 289 discharge directly to surface waters after on-site treatment, 393 discharge raw or partially treated wastewater to POTWs and 15 utilize both modes of discharge [16]. Over 25,000 organic chemicals, plastics and sythetic fibers are manufactured; less than half are made in quantities exceeding 1,000 lbs/yr.

In parallel, under the authority of RCRA, EPA has issued regulations for land disposal and deep well injection; promulgation of "land bans" was completed in May of this year. Evanoff describes the sequence and effective dates of these regulations [17]. He cites the effects of these limitations on aerospace industry activities. In addition, he discusses the roles of solvents and waste reducing alternatives in minimizing these effects on manufacturing processes.

SOLVENTS

Chlorinated aliphatic and aromatic hydrocarbons have a special niche in the hierarchy of hazardous and toxic substances. These species are employed as solvents, chemical intermediates and degreasing agents. In general, they are volatile, more dense than water, highly toxic to diverse organisms and interact with soil constituents, such as natural organic matter and clay minerals. They react with other compounds, in air, in the presence of ultra-violet radition. Wolf summarized the use of chlorinated solvents in cold cleaning, vapor degreasing and electronics manufacturing, in 1986 [18]. Use of 1,1,1-Trichloroethane (TCA) exceeds the combined uses of all other major solvents for cold cleaning. Trichloroethylene is a close second in vapor degreasing. Over the past two decades, industrial use of chlorinated solvents has shifted dramatically away from TCE to TCA [19]. This is a consequence of reduced toxic hazard and comparable solvent properties. The use of Perchloroethylene (PERC) has remained relatively constant at 0.6 to 0.7 billion lbs/yr.

Almost 0.5 billion gallons of waste solvent are disposed on land, annually, in the United States [20]. Of this quantity, about 97% is treated or stored in surface impoundments. This practice must cease under "land ban" regulations; Reference [20] is the Background Document for Solvent Restrictions. Evanoff tabulates candidate substitutes for the solvents in common use by the aerospace industry [17]. Water-based/alkaline cleaners can replace TCE, TCA, PERC and Freons in vapor degreasing; terpene-based cleaners can replace TCA, naphtha and methanol in cold-immersion cleaning. Also, Evanoff cites processes and process modifications suitable for recycle and reuse of aerospace industry hazardous wastes.

AUDITS

Means must be established to measure waste generation and waste reduction. Absolute elimination of hazardous waste can be achieved by plant closure; partial reduction accompanies reduced operation or abandonment of a waste-related product/process stream. These actions may have a positive environmental effect; however, they may have a very negative impact on industrial/community economy and growth. In short, source reduction and waste minimization must be evaluated in the context of vigorous, potentially expanding, industrial activity. Also, waste reduction must be monitored. The objective should be to sustain gains and to improve performance as technology advances. Appropriate mass balances, as discussed earlier, are the means of measuring and monitoring. Within the context of regulation, appropriate mass balances are termed "audits".

With the objective of establishing general guidelines for measurement of waste reduction, EPA undertook a series of trial waste minimization audits in 1987 and 1988, as follows:

Waste Type	EPA Report	Reference
Corrosive and Heavy Metal Waste	87/055	21
Cyanide Electroplating Waste	87/056	22
Solvent Waste from Electronic Parts Cleaning and Manufacturing	87/057	23
Printed Circuit Board Sludges and Solvent Wastes	88/008	24
Solvents and Electroplating Wastes (DOD)	88/010	25
Mercury Cell Chloralkali Plant Wastes	88/011	26

Recovery and recycle of calcium fluoride from stainless steel pickling liquor led to 30% reduction in waste volume and savings on raw material purchases [21]. Audits at two electroplating facilities encountered variability in the quality and availability of data [22]; the same was true for an audit of solvent wastes [23]. Metal-plating rinsewater sludges and solvents were audited and significant reduction attained in four of six printed circuit board facilities [24]. Drabkin and Sylvestri conducted audits at a generator of F002 and F004 wastes (spent solvents) and F006 wastes (wastewater treatment sludges from electroplating operations) [25]. Three source reduction options and two recycle/reuse options for cadmium/chromium waste, as well a source reduction option for chromium waste, were developed. Appropriate combination of these options could lead to delisting of the F006 wastewater sludge. Two alternative source reduction options were developed for paint stripping solvent. One source reduction option for a K071 waste was identified [26]; mercury cells could be replaced by membrane systems. Retorting of a mercury-bearing wastewater treatment sludge, for mercury recovery and recycle, was technically feasible and may be viable economically. A treatment option for detoxification of K071 waste appeared to be feasible.

Many States (MN, NC, NJ, PA, etc.) and Universities (CO St., TN, KY, etc.) have Technical Assistance Programs to assist small and medium-sized businesses with audits and advise on appropriate waste minimization technology. EPA has published a Manual for Waste Minimization Opportunity Assessment in an effort to generalize the audit process [27]. The Manual illustrates waste minimization assessment procedures; it is under evaluation by the NJTAP, a joint venture of NJIT and Rutgers University.

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CLEANER TECHNOLOGIES IN THE TANNING INDUSTRY

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The British Leather Confederation, which provides the Secretariat for the International Union of Leather Technologists and Chemists Environment and Waste Commission, is gathering information on clean technologies of leather manufacture, in co-operation with other leather industry associations. First results of this work will be presented as an example of the role that industrial associations can play in networking and promoting cleaner production.

Key aspects of the work are:

- Development of a practical database of clean technologies for the leather industry
- Development of networks of experts on clean technology for the leather industry

ENVIRONMENTAL IMPACT OF LEATHER PRODUCTION

Leather manufacture is one of the oldest established industries and has a current annual turnover of approximately US$25 billion, providing employment for around half a million workers on a worldwide basis(1). It is essentially a by-product industry, utilising hides and skins from animals raised primarily for their meat. Statistical information from the United Nations Food and Agriculture Organisation shows that in 1987 global leather production was nearly 14 billion square feet, produced from over 5 million tonnes of rawstock(2). In this sense the tanning industry considerably reduces the environmental impact of the meat industry, which would otherwise have a major waste disposal problem.

However, only approximately one-fifth of the rawstock can in practice be converted into saleable leather, the remainder forming wastes or by products. For example, some of the raw material, such as hair, soluble proteins and fat has to be removed during processing to prepare the collagen fibre structure of the hide for tanning and some parts of the leather also have to be trimmed or shaved during the production process. Residual chemicals from the leather manufacturing process contribute further to the tannery wastes. An indication of the amounts of liquid effluent and solid wastes or by-products resulting from the processing of 1 tonne of rawhide to leather is given in Figure 1.

A more detailed analysis of leather processing showing the stages at which chemical inputs are made and liquid effluent and solid wastes produced is given in Figure 2, and discussed below. The reader is also referred to a number of excellent reviews published in recent years that provide comprehensive information on the environmental impact of leather processing and pollution abatement, eg, The Technical Guide to Reducing the Environmental Impact of Tannery Operations (F Balkau; UNEP/IEO)(5); Pollution Abatement and Control in the Leather Industry (R L Sykes, D R Corning, British Leather Confederation; UNEP Industry and Environment Journal)(3); Environmental Impact Guidelines for New Source Leather Tanning and Finishing Industries (Wapora; US EPA)(6); Wastes from Tanning, Leather, Dressing and Fellmongering (UK DOE)(4).

LEATHER PRODUCTION AND WASTE MANAGEMENT

It can be seen in Figure 2 that after soaking hides to remove curing salt and soluble, non-collagenous proteins (eg, albumins), the hair and epidermal layer of the hide are degraded by chemical digestion of the hair/epidermal keratin with alkaline sodium sulphide. This unhairing step accounts for much of the BOD, COD, and suspended solids produced in the tannery effluent. The alkaline treatment also removes additional interfibrillary protein to open up the collagen fibre structure of the hide, which is essential for the production of soft leather. Although alkaline sodium sulphide itself poses few problems, toxic hydrogen sulphide gas would be evolved if the pH dropped in the effluent and most tanneries, at least in the developing countries, therefore, use a manganese catalysed aeration treatment originally developed by BLMRA(7) to comply with the low sulphide levels required by control authorities for discharges. Physico-chemical treatments are frequently employed to reduce the organic load and COD in the effluent (by around 50%) and to reduce the suspended matter by 80-90%. A typical tannery effluent treatment system is illustrated in Figure 3.

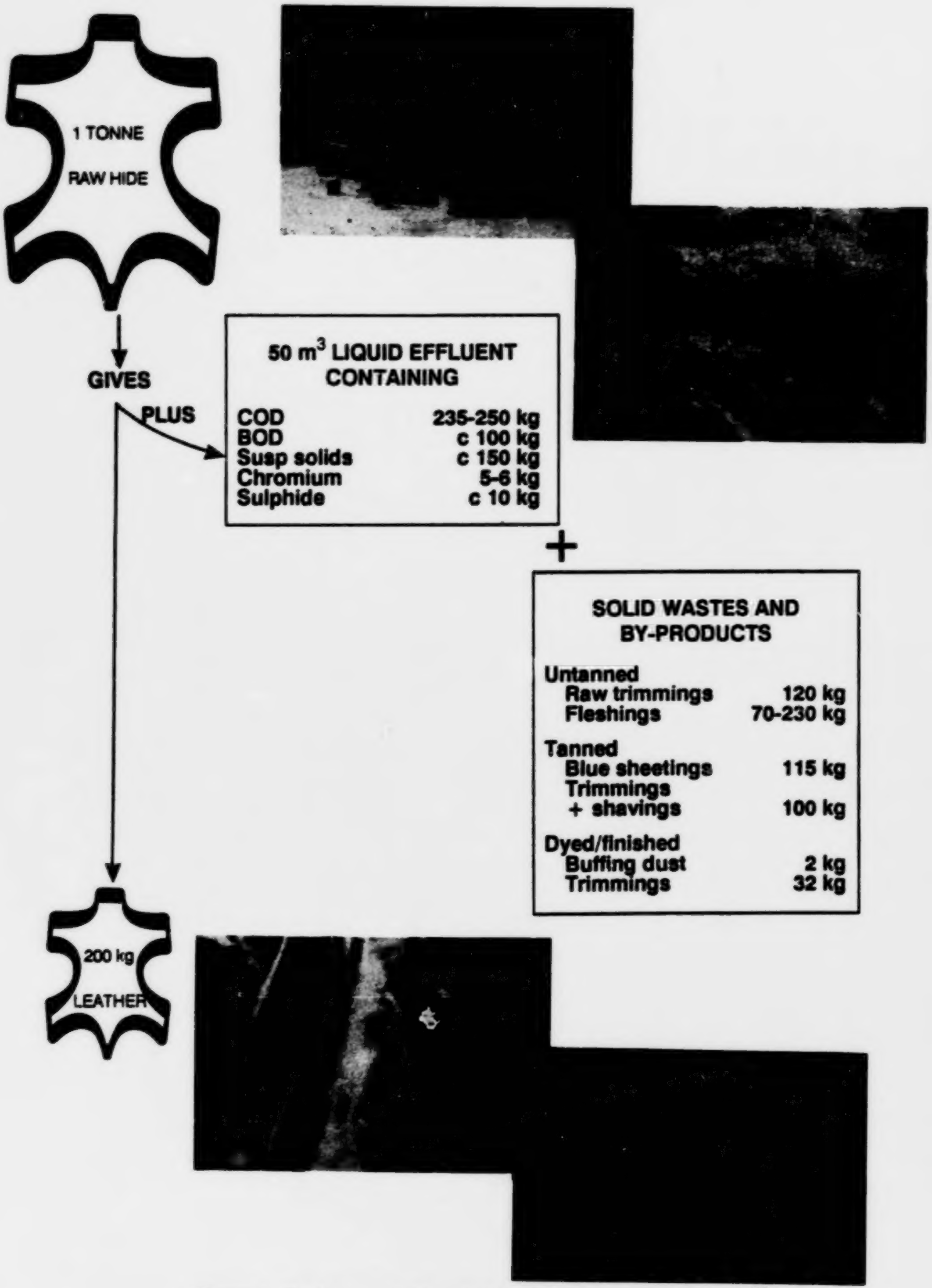


Figure 1 Environmental inpact of leather processing (source (3))

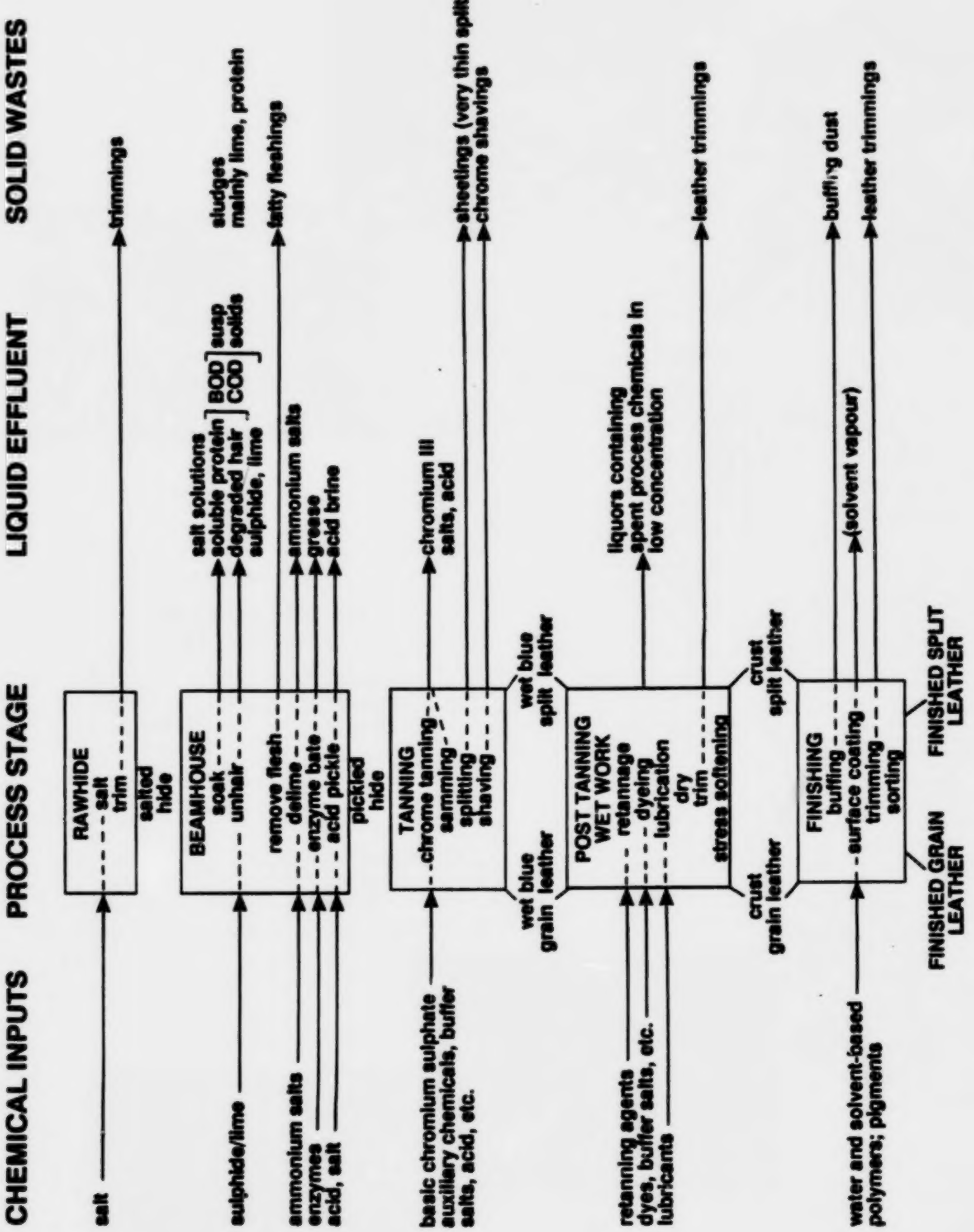


Figure 2 Chemical inputs and wastes produced during leather processing (source [4])

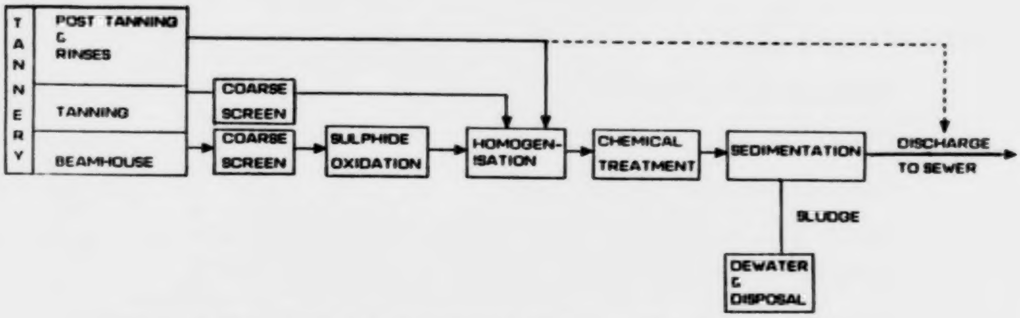


Figure 3 Physico-chemical treatment of tannery effluent (source [3])

Physico-chemical treatment requires initial balancing (homogenisation) of collected liquors followed by controlled addition of flocculants and sedimentation (or flotation) to remove sludge, which is, in most cases, then dewatered. Biological oxidation can provide a more effective treatment system for tannery effluent, although considerable land space is required. The oxidation ditch shown in Figure 4 reduces BOD levels in tannery effluent from 500-1000 mg/l down to levels as low as 1-2 mg/l residual BOD, with almost complete elimination of suspended solids and of ammonia, some of which is derived from the use of ammonium salts used for lowering the pH to prepare the skins for enzyme treatment (bating). The fatty fleshings that have to be removed from hides can be used as a source of tallow, although profitable disposal of chrome shavings produced after chrome tanning is difficult and often has to be disposed to landfill. Excess chromium (III) in the effluent is strictly controlled.

Figure 4 Oxidation ditch for biological oxidation treatment of tannery effluent (courtesy of W E & J Pebody Ltd, England)

Clean Technology and Pollution Control

Despite the fact that pollution abatement is a considerable, non-productive cost burden on leather manufacturers, the industry itself has taken the initiative in introducing cleaner technologies and improving pollution control. At the last meeting of the International Union of Leather Technologists and Chemists Societies in Philadelphia, USA in 1989 over 60% of the scientific papers presented were concerned with the development of cleaner technologies for leather manufacture[8]. In a recent survey of research directors of leather research organisations[9], clean technology was highlighted as the most important priority for future research, after cost reductions.

The key targets identified in that 1987 survey were:

- Replacement of chromium
- More effective use of chromium
- More efficient use of chemicals
- Sulphide free unhairing, possibly with hair recovery
- Utilisation of wastes
- Re-use of water
- Odour control
- Solvent free finishing
- N-free deliming

In fact many of these targets are now already being achieved and Figure 5 illustrates just a small selection of new clean technologies that are currently being introduced by the leather industry, or are already in place. These include:

- Hide chilling to avoid salt in the effluent
- Hair recovery processes to reduce BOD/COD of the effluent
- Enzyme-assisted unhairing to reduce sulphide
- CO_2 deliming to reduce ammonia in the effluent
- Better uptake/exhaustion of chrome or chrome recovery/recycling to reduce chrome in the effluent
- Alternative mineral tanning agents to avoid chrome in the effluent or solid wastes
- Water-based and solvent-free top coats to avoid VOC emissions

More detailed information on the processes are reported in the References cited in Figure 5.

Development of a Clean Technology Database for the Leather Industry

A lack of clear, objective and practically useful information is a major difficulty facing the busy tanner who wishes to introduce cleaner technologies of leather manufacture.

This need for an easily accessible source of information on clean technologies was the driving force behind the decision to set up a suitable database. The British Leather Confederation, which provides the Secretariat for the International Union of Leather Technologists and Chemists Environment and Waste Commission is therefore currently gathering information on clean technologies of leather manufacture, in co-operation with other leather industry associates. The work is dependent upon the development of a network of co-operation and support, involving

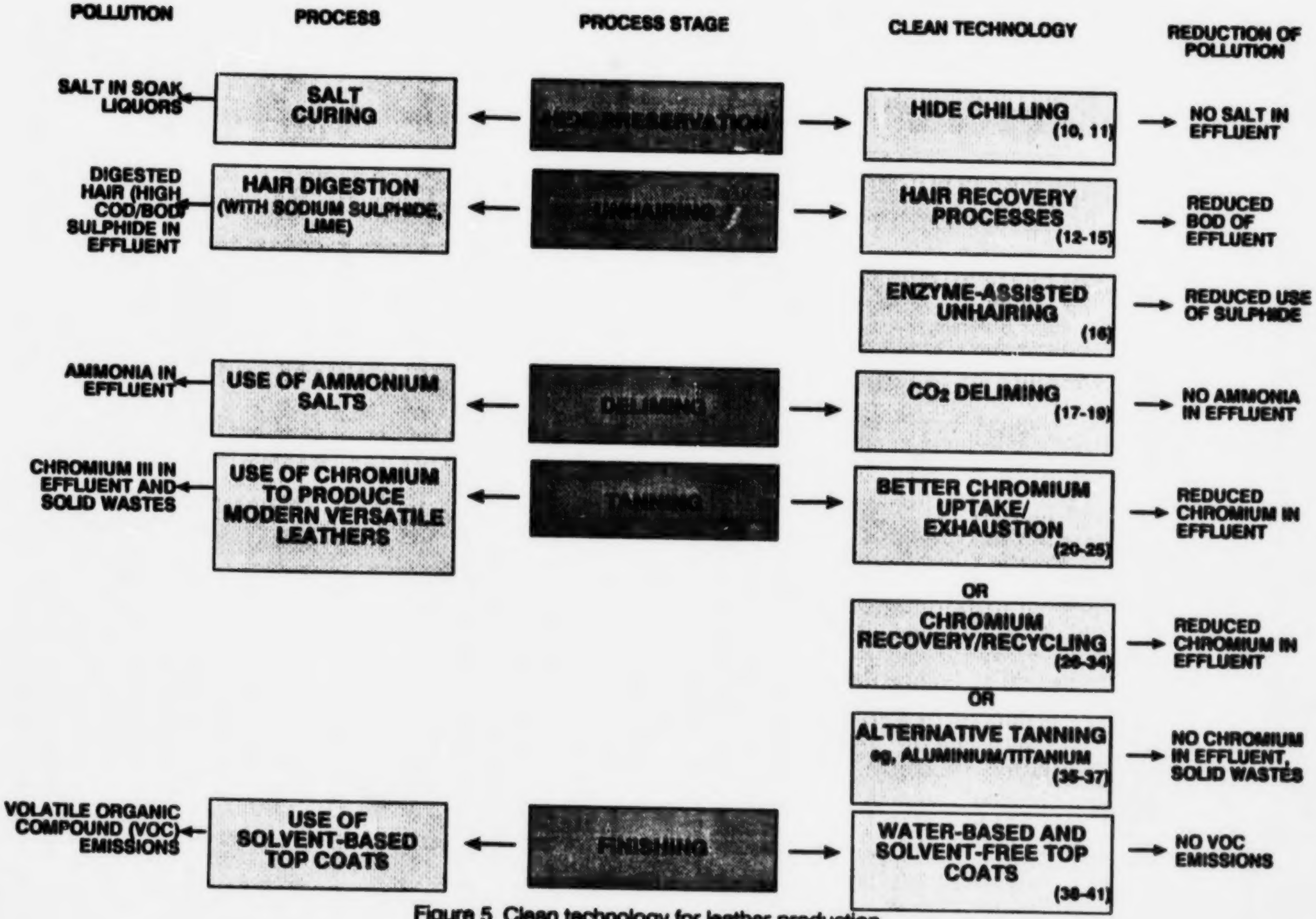

POLLUTION
PROCESS
PROCESS STAGE
CLEAN TECHNOLOGY
REDUCTION OF POLLUTION
SALT IN SOAK LIQUORS
SALT CURING
HIDE PRESERVATION
HIDE CHILLING (10, 11)
NO SALT IN EFFLUENT
DIGESTED HAIR (HIGH COD/BOD) SULPHIDE IN EFFLUENT
HAIR DIGESTION (WITH SODIUM SULPHIDE, LIME)
UNHAIRING
HAIR RECOVERY PROCESSES (12-15)
REDUCED BOD OF EFFLUENT
ENZYME-ASSISTED UNHAIRING (16)
REDUCED USE OF SULPHIDE
AMMONIA IN EFFLUENT
USE OF AMMONIUM SALTS
DELIMING
CO2 DELIMING (17-19)
NO AMMONIA IN EFFLUENT
CHROMIUM III IN EFFLUENT AND SOLID WASTES
USE OF CHROMIUM TO PRODUCE MODERN VERSATILE LEATHERS
TANNING
BETTER CHROMIUM UPTAKE/ EXHAUSTION (20-25)
REDUCED CHROMIUM IN EFFLUENT
OR
CHROMIUM RECOVERY/RECYCLING (26-34)
REDUCED CHROMIUM IN EFFLUENT
OR
ALTERNATIVE TANNING eg, ALUMINIUM/TITANIUM (35-37)
NO CHROMIUM IN EFFLUENT, SOLID WASTES
VOLATILE ORGANIC COMPOUND (VOC) EMISSIONS
USE OF SOLVENT-BASED TOP COATS
FINISHING
WATER-BASED AND SOLVENT-FREE TOP COATS (38-41)
NO VOC EMISSIONS

Figure 5 Clean technology for leather production

tanners, industrial research associations, industry suppliers, Government and other agencies (e.g. the European Commission under the SPRINT programme, the United Nations Environment Programme etc) and independent leather experts, as illustrated in Figure 6.

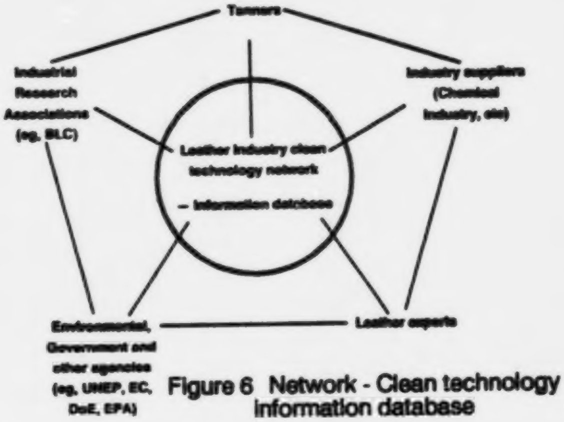
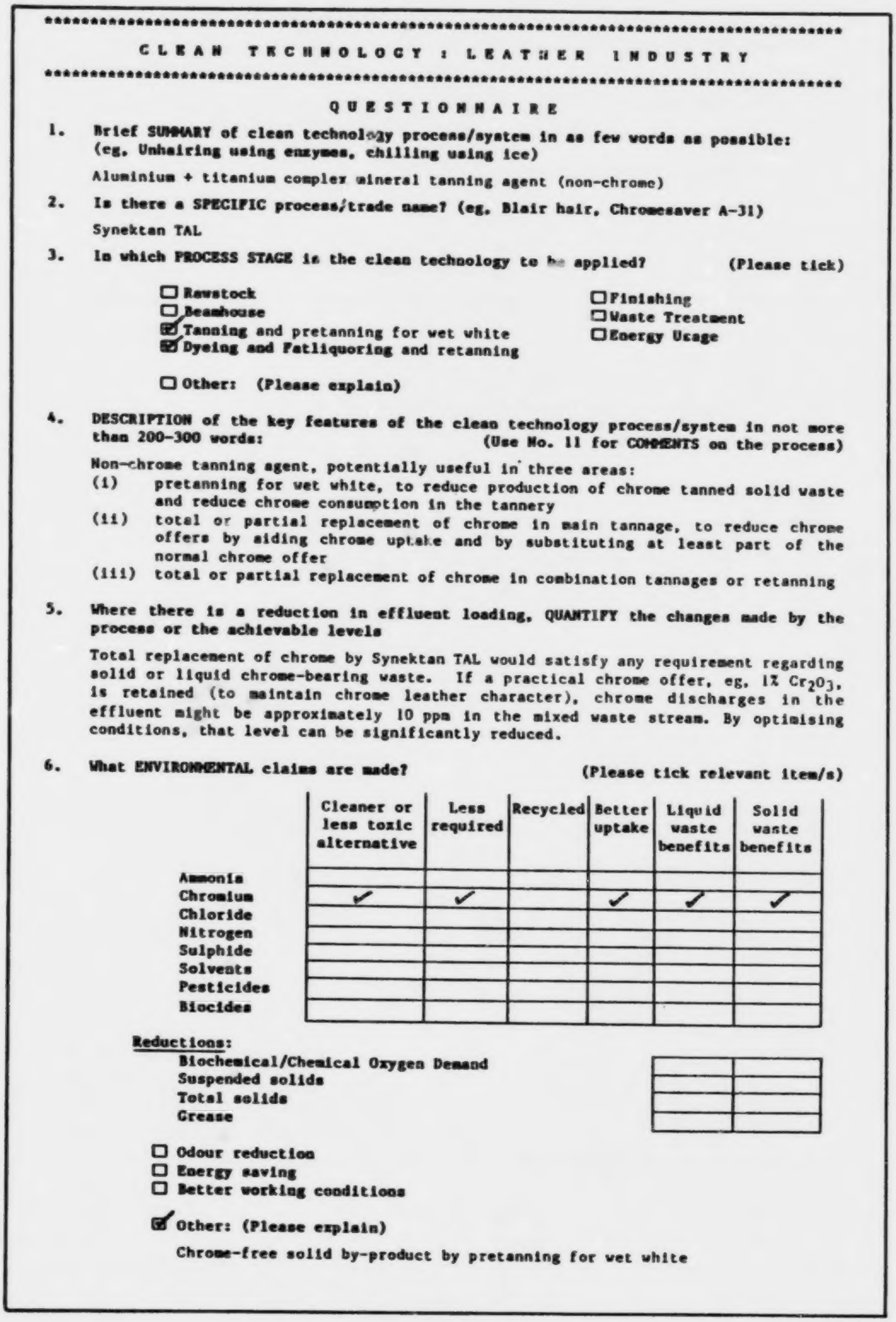

Tanners
Industrial Research Associations (eg. BLC)
Industry suppliers (Chemical Industry, etc)
Leather Industry clean technology network
– Information database
Environmental, Government and other agencies (eg. UNEP, EC, DoE, EPA)
Leather experts

Figure 6 Network - Clean technology information database

The main objective is to set up a practically useful system to enable the tanner to easily shortlist appropriate technologies for his requirements from the database. As part of this procedure it is also essential for the tanner to be able to identify existing users of the technology and independent leather experts, as well as the manufacturers or inventors, whom the tanner can then separately consult. It is considered most important that the database should not just be a bibliographic source of information but should be of immediate practical use, quantifying wherever possible the reductions in pollution achievable by the clean technology, listing any disadvantages and above all, giving an indication of its present level of development and extent of use, since systems inevitably range from those just at the research and development stage to well-established technologies in widespread use. An outline of the factors that have been selected for inclusion in the database is given in the Questionnaire reproduced in Figure 7, which in this particular example/case history has been completed for a new tanning product, Synektan TAL, manufactured by ICI as a replacement for chromium.

The leather industry has made considerable investments in time and money in reducing the pollution from tanneries and has achieved significant progress in introducing cleaner technologies, in collaboration with the suppliers. Nevertheless, because of the imposition of increasingly restrictive and sometimes unreasonable environmental legislation, many tanners have been forced out of business in recent years and the jobs of their workers lost because of the non-productive costs of improving environmental standards. In the recent survey of research directors of leather research organisations, one of the problems highlighted was the need to eliminate 'environmental hysteria'(9). It is to be hoped that in the years to come the legislative authorities will recognise the efforts of the tanning industry by setting realistic and scientifically based controls and avoiding, wherever possible, politically-motivated or emotional responses to the environmental problems facing all of us.

Figure 7 Clean Technology questionnaire



****

CLEAN TECHNOLOGY : LEATHER INDUSTRY

****

QUESTIONNAIRE

1. **Brief SUMMARY of clean technology process/system in as few words as possible: (eg. Unhairing using enzymes, chilling using ice)**

   Aluminium + titanium complex mineral tanning agent (non-chrome)

2. **Is there a SPECIFIC process/trade name? (eg. Blair hair, Chromesaver A-31)**

   Synektan TAL

3. **In which PROCESS STAGE is the clean technology to be applied? (Please tick)**

   ☐ **Rawstock**
   ☐ **Beamhouse**
   ☑ **Tanning** and pretanning for wet white
   ☑ **Dyeing and Fatliquoring** and retanning

   ☐ **Finishing**
   ☐ **Waste Treatment**
   ☐ **Energy Usage**

   ☐ **Other: (Please explain)**

4. **DESCRIPTION of the key features of the clean technology process/system in not more than 200-300 words: (Use No. 11 for COMMENTS on the process)**

   Non-chrome tanning agent, potentially useful in three areas:
   (i) pretanning for wet white, to reduce production of chrome tanned solid waste and reduce chrome consumption in the tannery
   (ii) total or partial replacement of chrome in main tannage, to reduce chrome offers by aiding chrome uptake and by substituting at least part of the normal chrome offer
   (iii) total or partial replacement of chrome in combination tannages or retanning

5. **Where there is a reduction in effluent loading, QUANTIFY the changes made by the process or the achievable levels**

   Total replacement of chrome by Synektan TAL would satisfy any requirement regarding solid or liquid chrome-bearing waste. If a practical chrome offer, eg. 1% Cr_2O_3, is retained (to maintain chrome leather character), chrome discharges in the effluent might be approximately 10 ppm in the mixed waste stream. By optimising conditions, that level can be significantly reduced.

6. **What ENVIRONMENTAL claims are made? (Please tick relevant item/s)**

	Cleaner or less toxic alternative	Less required	Recycled	Better uptake	Liquid waste benefits	Solid waste benefits
Ammonia						
Chromium	✓	✓		✓	✓	✓
Chloride						
Nitrogen						
Sulphide						
Solvents						
Pesticides						
Biocides						

Reductions:

Biochemical/Chemical Oxygen Demand		
Suspended solids		
Total solids		
Grease		

☐ **Odour reduction**
☐ **Energy saving**
☐ **Better working conditions**

☑ **Other: (Please explain)**
Chrome-free solid by-product by pretanning for wet white

7. **Quantify ADVANTAGES itemised above: (eg. 10% less salt in effluent)**

Practically, chrome in spent tan liquor might be reduced by 95%

8. **What DISADVANTAGES are there? (eg. aluminium in effluent) Please explain**
(Please tick relevant item/s)

☑ **Undesirable effects on the environment** - None at present; legislation may apply Consent Limits

☐ **High costs**

☐ **Technical problems**

☑ **Other:**

Post-tanning steps have to be modified to take account of Al + Ti in the leather

9. **How PRACTICAL is the clean technology? Please explain**

Very practical, no capital cost required or changes to existing processing methods

10. **Give an estimate of the 'CLEANNESS' of the process (Please tick relevant item/s)**

☐ Very good - Best possible
☑ Good - Best available to date
☐ Reasonable - Better than other processes
☐ Not so good - No better than other available processes

11. **Give an OPINION or make COMMENTS on the 'CLEANNESS' of the process:**

Synektan TAL can make real reductions in levels of discharged chrome with no current additional environmental problems. Discharges of aluminium (and possibly titanium) may be subject to environmental pressure in the future

12. **Name of ORGANISATION/MANUFACTURER responsible for clean technology:**

Contact name: Ian Tate
Company name: ICI Colours and Fine Chemicals
Address: PO Box 42, Hexagon House, Blackley, Manchester M9 3DA

Tel: 061 721 2562 **Telex:** 667841 **Fax:** 061 795 6005

13. **At what STAGE OF DEVELOPMENT is the process now? (Please tick relevant item/s)**

☐ Research & Development
☐ Trial/Prototype
☐ Other: (Please explain)
☐ Limited commercial use
☑ Widespread use

HOW MANY YEARS has the process/system been in commercial use? 2 years
WHAT YEAR was the process/system first developed? 1987 Product launched in 1988

14. **TANNERY COSTS AND PAY-BACK PERIOD**

IMPLEMENTATION COSTS:	PAY-BACK PERIOD:
☐ £1 - 5000	
☐ £5001 - 10,000	
☑ £10,001 - 50,000	5-10 years
☐ £50,001 - 100,000	
☐ More than £100,001	

15. **AVAILABILITY** **(Please tick relevant item/s)**

☑ Europe
☑ Asia
☑ Africa
☑ Australia & New Zealand
☑ N America
☑ S America

16. **Estimated NUMBER OF TANNERIES using the technology WORLDWIDE in year 2000:**

☐ 1-10
☐ 11-50
☐ 51-100
☐ 101-500
☑ More than 501

17. **ESTIMATED square feet of leather produced to date using this technology:**

☐ Less than 1 million square feet
☒ 1-5 million square feet
☐ More than 5 million square feet

18. **Give details of TANNERIES using this process who would be willing to be contacted:**

Contact name: Dr M P Walker
Organisation name: The British Leather Co Ltd
Type of business: Bovine tanners
Address: Tranmere Tannery, New Chester Road, Birkenhead, L41 9BS

Tel: 051 647 6252 **Telex:** 629570 **Fax:** 051 647 3573

19. **If IT IS NOT POSSIBLE to give above contacts, please give details of an INTERMEDIARY who could pass on any requests for information to a relevant tannery:**
See (12)

20. **Give full details of REFERENCES in the literature to the process:**
(Continue on a separate sheet if necessary)

A D Covington Tannages based on aluminium (III) and titanium (III) complexes
J Amer Leather Chem Assoc, 1987, 82, (1), 1

I Tate The use of aluminium, titanium and magnesium complexes in the pretanning, tanning and retanning operations
Proceedings, IULTCS Congress, Philadelphia, 1989

21. **Give details of any PRODUCT DATASHEET Reference Numbers:**
Product code 36003

22. **Give details of other sources of INFORMATION:**
Company information pack

23. **Which individuals are considered to be THE EXPERTS in this area?**

Name I P Tate/R M Webster
Organisation ICI Colours and Fine Chemicals
Address PO Box 42, Hexagon House, Blackley, Manchester M9 3OA

Tel: 061 721 2562 **Telex:** 667841 **Fax:** 061 795 6005

Name Dr M P Walker
Organisation The British Leather Co Ltd
Address Tranmere Tannery, New Chester Road, Birkenhead, L41 9BS

Tel: 051 647 6252 **Telex:** 629570 **Fax:** 051 647 3573

24. **Where information is obtained directly from the manufacturer, give details:**

Name: I P Tate
Organisation: ICI Colours and Fine Chemicals
Address: PO Box 42, Hexagon House, Blackley, Manchester M9 3OA

Tel: 061 721 2562 **Telex:** 667841 **Fax:** 061 795 6005

25. **Editor/Person completing this form:**

Name: Dr A D Covington
Organisation: British Leather Confederation
Address: Leather Trade House, Moulton Park, Northampton NN3 1JD

Tel: 0604 494131 **Telex:** 317124 **Fax:** 0604 648220

26. **Any COMMENTS not covered above:**

EC Supported Demonstration Project (ACE/88/UK/002/A21) currently being conducted at The British Leather Co Ltd, in collaboration with the British Leather Confederation

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Leder 1984 35 (4) 55-59

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WASTE MINIMIZATION - APPROACHES and TECHNIQUES

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225 West Washington Street
Chicago, Illinois 60606

ABSTRACT

This paper will present a series of suggested steps for conducting a waste minimization assessment, discuss means of inventory management and methods for improving operations. These suggested methods of assessment and process modification will be cast in the context of specific industrial waste streams in the automobile parts manufacturing and the metal finishing operations. The modification of any manufacturing process that has impacts on the receiving facility and/or POTW which receives the wastestream(s) will be discussed.

IMPACTS ON POTW's

WASTEWATER CHARACTERISTICS

Manufacturing facilities are now more than ever taking a closer look at waste streams that are generated from their operations. Discharges via smokestacks, sewers and refuse containers are being evaluated in an effort to reduce operating costs and storage requirements, improve public image and operating efficiency and to manage the potential risks and liabilities associated with waste disposal. Waste streams can be thought of as anything that doesn't go out the door as product. Waste can be in the form of a solid, liquid, gas, or a combination thereof and released into all environmental media. As materials are reused or reclaimed, they are considered a resource and no longer a waste.

This paper will evaluate the impact of waste minimization on publicly owned treatment plants (POTW's), and will therefore focus on wastewater discharges from the industrial facility. The wastewater characteristics should be evaluated to determine the volume and rate of water and contaminants that may be subjected to reduction and/or recycling.

SLUDGE PRODUCTION

The POTW treatment of industrial wastewaters will normally increase the sludge production. The impact of reducing the amount of sludge will usually result in less sludge requiring treatment and disposal. Care should be taken in instances where industrial wastewater flows are substantial not to adversely affect sludge operations at the POTW.

PRETREATMENT COMPLIANCE

Changes in the wastewater characteristics may also impact compliance with industrial pretreatment standards imposed by the POTW or regulatory agency. The most common impact is the concentration of contaminants by reducing wastewater flow rates; resulting in violations of concentration based standards. The higher concentration of contaminants may also not be amenable to treatment. An example would be the shock loading of BOD5 that was usually handled at a lower concentration.

TOXICITY

Changes in the flow rate or concentration of contaminants may also have an impact on the POTW. This is especially important when the treatment works involves biological tertiary treatment for nutrient removal or water reuse.

WASTE MINIMIZATION

REDUCTION

Waste reduction is reducing the volume or toxicity of waste through source reduction and recycling practices. Reduction is any in-plant activity that decreases the volume or toxicity at the point of generation. Source reduction is the environmentally preferred approach to waste reduction and usually provides the greatest economic benefits.

RECYCLING

Recycling is the use or reuse of a waste material in a process without changing its original form or reclamation by recovering secondary materials for a separate end-use or by removing impurities so that it may be reused. Recycling may generate a cashflow. It should not be selected as a waste minimization option solely on economics, since the receiving market value may vary greatly or be eliminated.

SOURCE REDUCTION

PRODUCT CHANGES

The process for identifying options should follow a hierarchy in which source reduction options are explored first, followed by recycling options. The reduction of the wastewater discharge at the generation source may involve substitution of a product, conservation of a critical material used or a change in the product composition.

SOURCE CONTROL

Changes in the input material that results in the wastewater discharge is the first point of evaluation. In many instances technology changes have been developed by others to reduce waste streams. Technical journals, trade publications and professional societies should be consulted. The most overlooked method of source reduction in the use of good operating practices to reduce waste generation.

RESULTS

Source reduction for waste minimization is the direct impact on the POTW. The changes in the wastewater will result in reduced discharge fees and /or pretreatment costs. Any proposed source control changes should be discussed with the operations personnel of the POTW.

RECYCLING

USE AND REUSE

Recycling via use and/or reuse involves the return of a waste material either to the originating process as a substitute for an input material, or to another process as an input material.

RECLAMATION

Reclamation is the recovery of a material from a wastestream. Reclamation techniques differ from use and reuse techniques in that the recovered material is not used in the facility, rather it is sold to another company.

RESULTS

The economic evaluation of recycling options should always include the cost of wastestream management under the current operation for comparison. The potential liabilities associated with improper disposal by others under contract should also be addressed.

WASTE MINIMIZATION ASSESSMENT PROCEDURE

PLANNING AND ORGANIZATION

Since effective waste minimization ideally involves the coordinated efforts of all personnel, the planning and organization are crucial to the success of a program. The development of a waste reduction and/of recycling program begins with obtaining management commitment, organizing a waste assessment team and setting realistic goals.

ASSESSMENT PHASE

The purpose of the assessment phase is to develop a comprehensive set of waste minimization options, and to identify the attractive options that deserve additional , more detailed analysis. In order to develop these waste minimization options, a detailed understanding of the industrial facility's wastes and operations is required. The assessment should begin by examining information about the processes, operations and waste management practices at the facility. This will serve as the baseline for comparison of options.

FEASIBILITY AND ANALYSIS PHASE

The remaining waste minimization options from the assessment phase are then evaluated based on technical and economic factors. The technical evaluation will determine whether a proposed option will work in a specific application within the industrial facility. Problems associated with facility building or operating constraints should be critically evaluated. Bench-scale or pilot testing may be necessary. Production requirements should be considered in the analysis as changes will affect the design criteria and operating parameters of the waste minimization option.

An economic evaluation is conducted by comparing the operating costs of the existing operation with the capital and operating costs of the proposed waste reduction option. The incremental operating costs should be determined. Capital costs include the costs for process equipment, construction materials, site preparation, installation, utility hook-ups, engineering, permitting, training and start-up. Operating costs include the costs of raw materials, maintenance, supplies, labor, utilities, waste transportation, disposal, storage and handling. Revenues from recycled waste can partially offset operating costs.

IMPLEMENTATION

It is good practice to implement the options that have low capital costs first. These options are usually easy to implement and result in significant waste reduction. The more capital intensive operations will be easier to implement after a track record has been established. For projects involving the purchasing of equipment, the installation of equipment should proceed in the same manner as other capital improvement projects.

WASTE STREAM CHARACTERISTICS

WASTEWATER

The critical waste minimization factor impacting POTW's is the change in the wastewater flowrates and contaminant concentrations. The discharge may also be intermittent as a result of batch operations or recycling. The impact on normal diurnal influent flowrates to the POTW should also be considered.

SLUDGE

Dissolved solids requiring further treatment at the POTW will result in the production of sludges for treatment and disposal. Biological waste sludges from the treatment of organic wastes will also be impacted by waste minimization. The treatment capacity at the POTW allocated to handling industrial wastewaters should also be evaluated for changes in capital and operating costs. Any reductions in these expenses may not be passed on to the discharger.

PROBLEM AREAS

DISCHARGE RATES

The most common problem with implementing waste minimization programs involving wastewater discharges to POTWs alteration of the discharge rate. Typical programs of reducing rinse water discharges or washdown waters may result in highly concentrated pollutants be discharged to the POTW.

CONCENTRATION OF POLLUTANTS

Impacts on the unit processes at the POTW and the maintenance of the NPDES discharge permit may be affected by changes in the concentration of pollutants. Both the process performance and reliability should be evaluated.

PRETREATMENT PROGRAM COMPLIANCE

Penalties imposed by violations or surcharge provisions in the industrial pretreatment code should be considered. Alternative wastewater disposal options may not be available. On-site treatment options rarely prove economical over the long term.

WASTE MINIMIZATION

Approaches and Techniques

Slide #1.

WASTE MINIMIZATION

IMPACT ON POTW's

- Wastewater Characteristics
- Sludge Production
- Pretreatment Compliance
- Toxicity

Slide #2.

WASTE MINIMIZATION

- Reduction
- Recycling

Slide #3.

SOURCE REDUCTION

- Product Changes

- Source Control
  - Input Materials
  - Technology
  - Operations

Slide #4.

RECYCLING

- Use and Reuse
- Reclamation

Slide #5.

WASTE MINIMIZATION ASSESSMENT PROCEDURE

- Planning and Organization
- Assessment Phase
- Feasibility and Analysis Phase
- Implementation

Slide #6.

WASTE STREAM CHARACTERISTICS

- Wastewater
  - Liquid Fraction
  - Solids Percentage
- Sludge
  - Moisture Content
  - Handling and Storage

Slide #7.

PROBLEM AREAS

- Discharge Rates
- Concentration of Pollutants
- Pretreatment Compliance

Slide #8.

International Conference on Pollution Prevention:
Clean Technologies and Clean Products

Session 37: Hazardous Waste Minimization in DoD Operations
Washington, DC - June 12, 1990

THE ARMY'S HAZARDOUS WASTE MINIMIZATION PROGRAM

by
Robert P. Bartell, Janet L. Mahannah & Michael J. Dette
Research and Technology Development Branch
U.S. Army Toxic and Hazardous Materials Agency

ABSTRACT

The Army engages in a wide variety of activities including manufacturing, maintenance, and testing operations. These operations result in the generation of a wide variety of hazardous wastes such as solvents, sludges, acids, bases, and heavy metal-contaminated materials. Reducing the volume and toxicity of these wastes presents significant challenges for all levels of Army management. To respond to these challenges, the Army has developed a comprehensive hazardous waste minimization (HAZMIN) program.

The following initiatives are part of the Army's program: systems to help the potential hazardous waste generator track hazardous material use and disposal; a HAZMIN awards program to stimulate waste minimization ideas; a hazardous waste source reduction study to identify and evaluate opportunities for HAZMIN in the material acquisition life cycle process; and research, development, and implementation of technologies, processes, or materials to result in HAZMIN. Ongoing research and development efforts are directed to accomplishing HAZMIN through material substitution, operational changes, and by-product recovery and reuse.

The Army HAZMIN program has seen tremendous change and growth in the past five years, and current goals to dramatically reduce the generation of hazardous waste are indicative that this change and growth will continue. Ongoing HAZMIN initiatives are directed toward meeting these goals.

VIEWGRAPHS

THE ARMY'S HAZARDOUS WASTE MINIMIZATION PROGRAM

ARMY HAZMIN GOAL

To reduce hazardous waste generation
by 50% by the end of 1992
using FY 1985 total as baseline

ARMY HAZMIN PROGRAM

STATUS
Tracked Waste (1000 Metric Tons)

1985	1986	1987	1988	1989	1990	1991	1992
98	126	60	59	112*	---------------->		49

* Includes 60,000 metric tons generated during two RCRA closures

---

HAZARDOUS WASTE GENERATION (CY 1989)

92%	Army Materiel Command (AMC)
6%	Forces Command (FORSCOM)
2%	Training & Doctrine Command (TRADOC)

HAZARDOUS WASTE GENERATION

Relative generation per selected operation in AMC

Spills	-
Motor pool	--
Surface treatment	-------------
Ammunition disposal	----------------
Energetics production	-------------------
	Quantity --->

MAJOR HAZARDOUS WASTE CATEGORIES

- PEP: Propellants
  Explosives
  Pyrotechnics
- Organic solvents
- Heavy Metals

TACTICAL VEHICLE MAINTENANCE HAZARDOUS WASTE GENERATION

```
                    ----------->  SLUDGES
PAINTING                               Excess paint
DEPAINTING                             Stripped Paint
DEGREASING                             IWTP sludge
CLEANING            ----------->  AIR EMISSIONS
ELECTROPLATING                         Volatile organics
                    ----------->  AQUEOUS/LIQUID WASTES
                                       Rinse waters
                                       Spent strippers
                                       Spent plating baths
```

HAZMIN CHALLENGE

REDUCE OR ELIMINATE GENERATION OF HAZARDOUS WASTES
- Materials Substitution
- By-product recovery/reuse
- Operational changes

RESULTS
- Improved production rates
- Improved product quality
- Decreased operating costs

ROLE OF R&D IN HAZMIN

```
APPLICATION OF EXISTING TECHNOLOGIES
     To new situations
     To meet Army-specific requirements
     To fit into existing processes
      |
      |  INNOVATIVE TECHNOLOGY DEVELOPMENT
      |       New processes
      |           |
     \|/         \|/      METHODS
     IMPLEMENTATION            Material substitution
                               Operational changes
                               By-product recovery/reuse
```

ARMY HAZMIN TECHNOLOGIES UNDER DEVELOPMENT

RECOVERY/REUSE
- Requalification/recycle of off-grade TNT during production
- RDX and TNT as fuel supplements for installation heating plants
- Recovery of propellants for reuse by resolvation

PROCESS CHANGE
- Aluminum ion deposition as an alternative to electroplating
- Plastic media blasting for paint stripping
- Fluidized bed paint stripping for small parts
- More effective paint application techniques
- Extension of stripping solutions by dialysis and filtration

MATERIALS SUBSTITUTION
- Alternate chemical paint stripper formulations

PLASTIC MEDIA BLASTING DEMONSTRATION

Benefits realized from replacement of obsolete equipment with state-of-the-art plastic media blasting booth

WASTE REDUCTION
- High efficiency recycle system and pressure control reduces waste generation by 70% (annual waste production is reduced by 93,000 lbs)

LABOR REDUCTION
- Automatic floor recovery reduces labor requirements by 25% (1250 manhours per year)

COST REDUCTION
- Estimated yearly cost savings of $63,000 - $210,000

OTHER BENEFITS
- Greater variety of parts processed
- Cleaner, healthier, and safer environment for operators

ALTERNATIVE CHEMICAL STRIPPER IDENTIFICATION AND EVALUATION

OBJECTIVE

Identify and evaluate commercially-available strippers to replace current formulations containing methylene chloride

SUCCESSFUL STRIPPER MUST:
- Reduce TTO contributions
- Effectively strip a variety of coating/substrate combinations within 2 hours
- Meet operational, health, and safety requirements

ALUMINUM ION VAPOR DEPOSITION

OBJECTIVE

Demonstrate that aluminum ion vapor deposition is a viable alternative to cadmium corrosion protection plating

VALUE

Reduce generation of hazardous wastes resulting from cadmium plating operations

METHOD

AIVD unit to be purchased and installed at Anniston Army Depot. Testing/demonstration to determine applicability and operating parameters. Implementation to be pursued where appropriate.

FLUIDIZED PAINT REMOVAL

OBJECTIVE

Demonstrate the use of a heated bed of fluidized aluminum oxide to remove grease and paint from parts at Army depots

VALUE

Reduce reliance on chemical stripping
- Reduce generation of hazardous waste
- Provide better worker environment

METHOD

Fluidized bed unit to be purchased and installed at Red River AD. Testing/demonstration to determine applicability and operating parameters. Implementation pursued where appropriate.

FILTRATION OF PAINT STRIPPING BATHS

OBJECTIVE

Demonstrate the potential for extending the life span of paint stripping baths by filtration

VALUE

- Reduce generation of hazardous waste
- Reduce costs associated with treatment/disposal
- Reduce raw material costs

METHOD

Filtration unit to be purchased and installed at Letterkenny AD. Testing and demonstration will be conducted to determine feasibility, effectiveness, cost, and to develop guidelines for system implementation wherever appropriate.

HIGH EFFICIENCY PAINT APPLICATION

OBJECTIVE

Demonstrate the use of high efficiency paint application systems to increase transfer efficiencies and reduce hazardous waste generation and VOC emissions

VALUE

- o Reduce generation of hazardous waste
- o Reduce VOC emissions
- o Reduce costs associated with treatment/disposal
- o Reduce material costs

METHOD

Three high efficiency paint application systems will be purchased and tested at Sacramento AD. Test analyses will include transfer efficiency, rate of application, and ability to meet coating specifications. Information to provide for guidance for other depots.

ELECTRODIALYSIS OF CHROMIC ACID SOLUTIONS

OBJECTIVE

Demonstrate the potential for increasing the life span of chromic acid solutions

VALUE

- o Reduce generation of hazardous waste
- o Reduce costs associated with treatment/disposal
- o Reduce material costs

METHOD

Electrodialysis unit to be purchased and installed at Corpus Christi AD. Testing/demonstration will be conducted to determine potential for waste reduction and to develop performance criteria for implementation.

PROPELLANTS/EXPLOSIVES/PYROTECHNICS
HAZARDOUS WASTE GENERATION

OPERATION

- o Production of energetic material
- o Assembly of rounds

WASTE FORMS

- o Sludges
- o Wastewaters
- o Air emissions

OPPORTUNITIES FOR HAZMIN

- o Material substitutions?
- o Process changes?

WHAT'S LEFT? - RECOVERY/REUSE

OPPORTUNITIES

- Solvation of propellants for reconfiguration
- Rework/recycle of off-grade TNT during production
- Use of waste explosives as fuel oil supplements
- Activated carbon regeneration
- Reuse of explosives in munitions
- Use of propellants as fuel supplements

KEY WORDS

- IMPLEMENTATION
- COST

INHERENT PROBLEMS IN IMPLEMENTING NEW TECHNOLOGY

- Performing accurate cost analysis
- User acceptance
- Acquisition of operating/construction funds

SUMMARY

- Three primary means to reduce the generation of hazardous wastes:
  - Recovery/Reuse
  - Process Changes
  - Material Substitution
- Opportunities currently exist to reduce hazardous waste generation in ways that will reduce operating costs and at least maintain, or improve, product quality
- Current emerging technologies can be adapted to site/application-specific operations to accomplish the above
- As more HAZMIN measures are implemented, more innovation will be required to accomplish the above
- In the absence of future innovation, more HAZMIN can be expected to require higher operating costs
- An interface of real substance must be established between user and developer in order to effectively benefit from new HAZMIN technology

END

CORPORATE TRANSITION TO MULTI-MEDIA WASTE REDUCTION
MEASURING WASTE REDUCTION PROGRESS

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LACK OF DATA

One of the impediments identified in the NWF CCC policy statement Dr. Bringer listed in the introduction was "Lack of Useful Data on Progress."

In the policy statement itself it appears as "Lack of consistent and useful data on the extent and effect of industrial source reduction." Source reduction here means preventing the generation of waste.

WHAT IS NEEDED

If this is to change, two things have to happen:

1. Companies need to do a better job of keeping track of projects that reduce wastes and releases. They need to keep track of successes and failures for existing and new products.

2. The government needs to develop a better understanding of how to collect good data from very varied manufacturing operations.

Reliable data showing where and how much waste minimization is taking place would be helpful in furthering the cause of pollution prevention.

1. It would provide trend data to show the Agency where promotion of waste minimization is needed most. Also, it would show where to focus our efforts, taking into consideration other factors, such as potential exposure, fate, and public concerns.

2. It would identify successful waste minimization projects that would be prioritized for technology transfer.

USEPA REPORT TO CONGRESS

In its report to Congress in 1986 on waste minimization, the USEPA concluded that waste minimization is taking place, but that it is hard to quantify.

The recommended strategy suggested was to gather detailed data through 1989 using RCRA reports. Based on the results, the Agency would prepare a waste minimization report to Congress in 1990 with recommendations for legislative changes if they were needed.

REASONS FOR LACK OF GOOD DATA

Unfortunately, there have been difficulties collecting the detailed data. Some of the reasons for the lack of good data are:

1. Generation prevention (source reduction) is hard to quantify, because when you stop generating waste, it isn't around to measure.

2. The ability to quantify waste minimization is simpler with a facility manufacturing a single product, than with a multi-product facility with combined waste streams.

   Most of 30,000 large quantity generators, and more than 100,000 small quantity generators, are multi-product facilities that make many products and combine the waste streams.

   For multi-product facilities with combined waste streams, waste minimization progress cannot simply be determined by taking the annual difference in combined waste streams adjusted for average production.

3. Another reason for lack of good data is most multi-product companies have not kept track of completed waste minimization projects.

   This is because in many cases the effort is part of a larger project, and after getting the job done, the engineers have had other priorities. Also, many projects are initiated and completed in a plant by workers, who never make a record of their work.

4. Still another reason, is that the initial format the Agency used to collect waste minimization data using the RCRA biennial report was seriously flawed for multi-product manufacturing facilities with combined waste streams.

   The format was changed for the 1989 reporting year; however, it's unclear if the change was effective. Also, it's not clear if the Agency has the resources to evaluate and utilize the data collected in time for the 1990 report.

5. The last reason why data collection has been difficult is that the forms themselves are intimidating. They are complex, asking for details not needed, in industry's view, and they have complex instructions. Many of the detailed questions ask for data not readily available and are of questionable value. The forms are resource intensive for the companies to fill out, and also resource intensive for the Agency to validate and interpret the results.

MINNESOTA EXPERIENCE

Experience in Minnesota with the USEPA waste minimization forms for 1987 showed that more than half of the persons filling out the forms are nontechnical -- accountants, personnel managers, presidents, laborers, etc.

They are intimidated by complex, detailed technical questions and instructions.

The reliability of the responses to a questionnaire decreases, as complexity increases.

EXAMPLES - PROBLEMS WITH MULTI-PRODUCT FACILITIES

With that background, here are examples comparing the problems with data collection for multi-product manufacturing companies with single product manufacturing:

o	Slide 1	Single product vs. multi-product
o	Slide 2	Single product without waste minimization
o	Slide 3	Single product with waste minimization
o	Slide 4	Multi-product without waste minimization
o	Slide 5	Multi-product with waste minimization.

RECOMMENDATIONS

I have two recommendations that would improve the measurement of waste reduction progress:

1. The Agency should provide an option (Slide 6), clearly stated, for multi-product facilities to be able to report estimated results of waste minimization projects that prevent the generation of waste.

   Here's an example (Slide 7) of how companies can collect data by projects and report estimated results. This is a summary of how 3M keeps track of 3M Pollution Prevention Pays (3P) Projects.

   If data are collected in this way, it will be useful for showing trends of generation prevention progress (Slide 8).

2. The RCRA waste minimization forms should be made self-explanatory.

   A good example would be the U.S. Census Forms that we all just completed. Based on the simple census form I filled out, I'd say most of the people completed the form without needing to read the separate instructions.

   Here's an example of the USEPA RCRA waste minimization form made self-explanatory (Slide 9).

The best way to ensure getting good data is to keep it simple. Don't make it a resource intensive activity for the company and the Agency.

Plant personnel don't have a lot of spare time to fill out the forms. The agencies do not have the money and manpower to analyze and to interpret resource intensive forms. Much of the data already collected will never be looked at.

FUTURE POSITIVE ACTION

On the positive side, industry is working with the Agency towards improving the data collection process.

At the last meeting of the American Institute of Pollution Prevention (AIPP), arrangements were made for the Implementation Council to meet with Mr. Gerald Kotas, Director of the Office of Pollution Prevention, and his staff, on the matter.

Anyone interested in waste minimization measurement is invited to join us.

SLIDE 1

WASTE MIN PROGRESS
DATA COLLECTION

SINGLE PRODUCT MFG
Unmixed Wastes

MULTI–PRODUCT MFG
Combined Waste Streams
Mixed Wastes

SLIDE 2

DEDICATED SINGLE PRODUCT OPERATION
CASE I – WITHOUT WASTE MINIMIZATION PROJECT

SIC CODE --------   WASTE CODE --------

YEAR	UNITS OF PRODUCT	TONS WASTE GENERATED ACTUAL REPORTED	TONS WASTE GENERATED EXPECTED*	TONS WASTE PREVENTED	INDEX ~
1986	75	150	–	–	2
1987	150	300	300* CALCULATED	ZERO	2

* EXPECTED = 1986 TONS MULTIPLIED BY PRODUCTION RATIO
PRODUCTION RATIO 1987/1986 = 2

~ INDEX = ACTUAL TONS WASTE PER UNIT PRODUCT

SLIDE 3

DEDICATED SINGLE PRODUCT OPERATION
CASE II – WITH WASTE MINIMIZATION PROJECT

SIC CODE ________ WASTE CODE ________

YEAR	UNITS OF PRODUCT	TONS WASTE GENERATED ACTUAL REPORTED	TONS WASTE GENERATED EXPECTED*	TONS WASTE PREVENTED	INDEX ^
1986	75	150	–	–	2
1987	150	150	300* CALCULATED	150	1

* EXPECTED = 1986 TONS MULTIPLIED BY PRODUCTION RATIO
PRODUCTION RATIO 1987/1986 = 2

^ INDEX = ACTUAL TONS WASTE PER UNIT PRODUCT

SLIDE 4

MULTI PRODUCT OPERATION – COMBINED WASTE STREAMS
CASE I – WITHOUT WASTE MINIMIZATION PROJECT

SIC CODE _____ WASTE CODE _____

	PRODUCT	UNITS OF PRODUCT	PROD RATIO 1987/1986	TONS WASTE GENERATED ACTUAL REPORTED	TONS WASTE GENERATED EXPECTED*	TONS WASTE PREVENTED	INDEX ACTUAL TONS WASTE PER UNIT OF PRODUCT
1986	A	35		15			.43
	B	50		10			.20
	C	15		5			.33
	AGGREGATED TOTAL	100		30			.30

				TONS WASTE GENERATED ACTUAL REPORTED	TONS WASTE GENERATED EXPECTED*		
1987	A	70	2	30			.43
	B	25	1/2	5			.20
	C	30	2	10			.33
	AGGREGATED TOTAL	125	1.25 AVG	45	37.5*	APPARENT INCREASE 7.5 TONS	.36

* 1986 TONS MULTIPLIED BY PRODUCTION RATIO

SLIDE 5

MULTI PRODUCT OPERATION – COMBINED WASTE STREAMS
CASE II – WITH WASTE MINIMIZATION PROJECT

SIC CODE _____ WASTE CODE _____

	PRODUCT	UNITS OF PRODUCT	PROD RATIO 1987/1986	TONS WASTE GENERATED ACTUAL REPORTED	TONS WASTE GENERATED EXPECTED*	TONS WASTE PREVENTED	INDEX ACTUAL TONS WASTE PER UNIT OF PRODUCT
1986	A	35		15			.43
	B	50		10			.20
	C	15		5			.33
	AGGREGATED TOTAL	100		30			.30

				TONS WASTE GENERATED ACTUAL REPORTED	TONS WASTE GENERATED EXPECTED*	TONS WASTE PREVENTED	
1987	A	70	2	22.5		7.5	.43
	B	25	1/2	5			.20
	C	30	2	10			.33
	AGGREGATED TOTAL	125	1.25 AVG	37.5	37.5*	APPARENT NONE	.30

* 1986 TONS MULTIPLIED BY PRODUCTION RATIO

SLIDE 6

Clearly Show Options

Sec II **Results of project or activity**
Show Quantity of Waste Prevented or Newly Recycled
Complete either Item 1 or Item 2 - Describe in Section III

PROJECT ☐ Prevented Generation or
☐ Newly recycled

Item 1. Single Uncombined Waste Stream - Single Product Manufacturing
A. 1987 Quantity Generated ______ ☐ Tons
☐ Pounds
B. 1988 Quantity Generated ______ ☐ Gals. ______ lb/gal
C. Production Ratio ______
D. Calculate Quantity Prevented or Newly Recycled in year reported

A x C - B = ____________________ Prevented ☐ Onsite ☐
Newly Recycled ☐ Offsite ☐

Item 2. Combined Waste Streams - Multi-Product Manufacturing
A. Estimate Quantity Prevented in year reported _________ ☐ Tons
Explain Estimate in Section III ☐ Pounds
B. Quantity Newly Recycled in year reported ___________ ☐ Gals. ________ lb/gal

Sec. III **A Narrative description of waste minimization project or activity and results achieved.**

SLIDE 7

TRACKING WASTE MINIMIZATION PROJECTS
DATA SUMMARY
TABLE 1.

PROJECT NAME	DATE	PLANT	AIR	WATER	W/W	SOLID	HAZ.
			POLLUTANTS PREVENTED (TONS/YR)				
REFORMULATION	1987	A				1	1
RADIATION POLYMER.	1987	B	3000				
VAPOR DEG/ SOLV. SUB.	1987	C	45				
FREON REPLACE/ IN CANS	1987	D	313			430	430
SPRAY DRIED/ LEAD ELIM.	1988	E	430	3.5			
ALTERN. EMULSIFIER	1988	F				643	327
HIGH SOLID ADHESIVE	1988	G	332				
ZINC OXIDE REDUC.	1988	H				70	70

SLIDE 8

EXAMPLE
FIGURE 3. SUMMARY WASTE MINIMIZATION TRENDS

SICO CODE 000 LARGE QUANITY GENERATOR COMPANY
WASTE CODE F-000

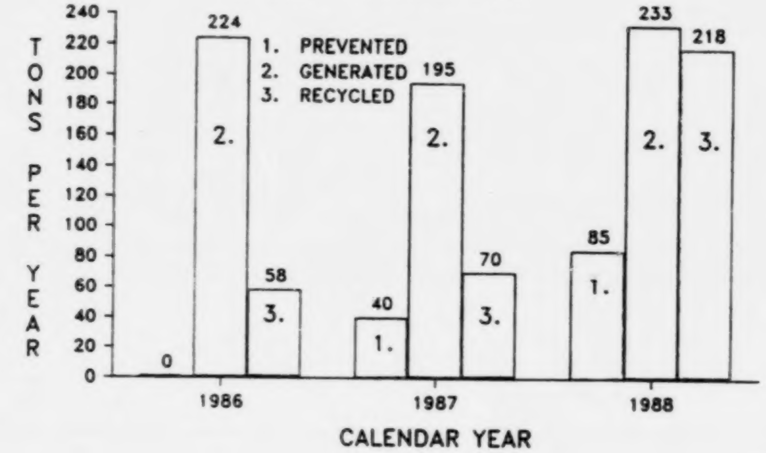
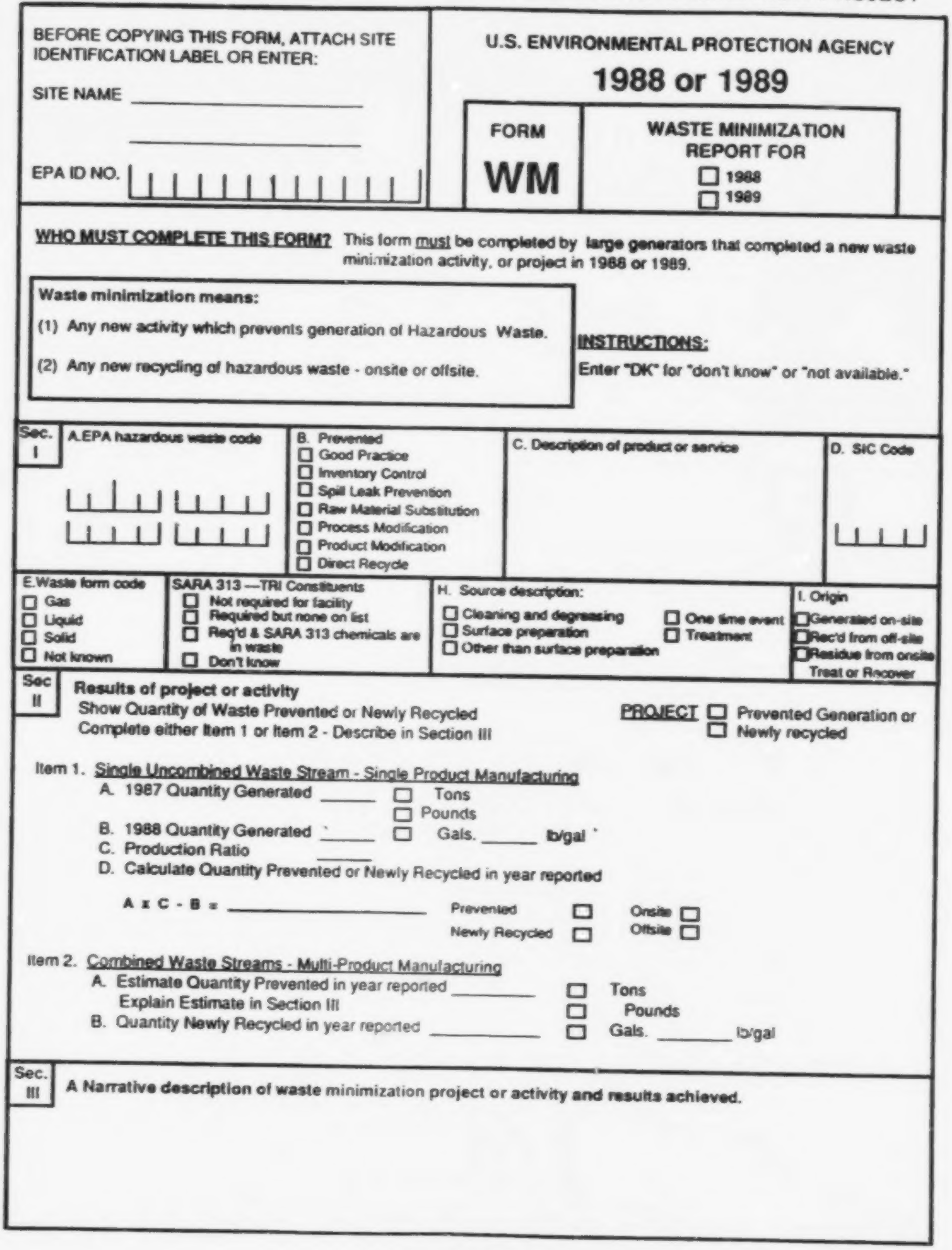


FIGURE 4. INDUSTRIES' ONE PAGE, SELF-EXPLANATORY PROPOSED FORM
MAKE A COPY OF THIS FORM FOR EACH NEW WASTE MINIMIZATION PROJECT



BEFORE COPYING THIS FORM, ATTACH SITE IDENTIFICATION LABEL OR ENTER:

SITE NAME ____________________

____

EPA ID NO. |_|_|_|_|_|_|_|_|_|_|_|_|

U.S. ENVIRONMENTAL PROTECTION AGENCY

1988 or 1989

FORM **WM**

WASTE MINIMIZATION REPORT FOR
☐ 1988
☐ 1989

WHO MUST COMPLETE THIS FORM? This form must be completed by **large generators** that completed a new waste minimization activity, or project in 1988 or 1989.

Waste minimization means:

(1) Any new activity which prevents generation of Hazardous Waste.

(2) Any new recycling of hazardous waste - onsite or offsite.

INSTRUCTIONS:

Enter "DK" for "don't know" or "not available."

Sec. I

A. EPA hazardous waste code
|_|_|_|_| |_|_|_|_|
|_|_|_|_| |_|_|_|_|

B. Prevented
☐ Good Practice
☐ Inventory Control
☐ Spill Leak Prevention
☐ Raw Material Substitution
☐ Process Modification
☐ Product Modification
☐ Direct Recycle

C. Description of product or service

D. SIC Code
|_|_|_|_|

E. Waste form code
☐ Gas
☐ Liquid
☐ Solid
☐ Not known

SARA 313 —TRI Constituents
☐ Not required for facility
☐ Required but none on list
☐ Req'd & SARA 313 chemicals are in waste
☐ Don't know

H. Source description:
☐ Cleaning and degreasing
☐ Surface preparation
☐ Other than surface preparation
☐ One time event
☐ Treatment

I. Origin
☐ Generated on-site
☐ Rec'd from off-site
☐ Residue from onsite Treat or Recover

Sec II

Results of project or activity
Show Quantity of Waste Prevented or Newly Recycled
Complete either Item 1 or Item 2 - Describe in Section III

PROJECT ☐ Prevented Generation or
☐ Newly recycled

Item 1. Single Uncombined Waste Stream - Single Product Manufacturing
A. 1987 Quantity Generated _____ ☐ Tons
☐ Pounds
B. 1988 Quantity Generated _____ ☐ Gals. _____ lb/gal
C. Production Ratio _____
D. Calculate Quantity Prevented or Newly Recycled in year reported

A x C - B = ____________________ Prevented ☐ Onsite ☐
Newly Recycled ☐ Offsite ☐

Item 2. Combined Waste Streams - Multi-Product Manufacturing
A. Estimate Quantity Prevented in year reported ________ ☐ Tons
Explain Estimate in Section III ☐ Pounds
B. Quantity Newly Recycled in year reported ________ ☐ Gals. _______ lb/gal

Sec. III

A Narrative description of waste minimization project or activity **and results achieved.**

SLIDE 9

Creating the Conditions for Sustainable Development: Programmes and Instruments for Pollution Prevention

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INTRODUCTION

There is at present considerable interest worldwide in programmes designed to encourage environmentally less damaging behaviour; it can be argued that this interest has been spurred on by such factors as the Brundtland Commission Report, highlighting the need for sustainable development and concern about both global issues (eg the Greenhouse effect) and local issues (eg Hazardous waste).

This paper examines what this might mean in practice and in particular draws on:

- the National Environment Policy Plan established by the Netherlands Government and the concept of "integrated life cycle management" intended as a framework for fundamentally reducing resource use and waste production;
- the experience in OECD countries of employing different forms of instrument that can be used to implement sustainable development policies

PROGRAMMES

Integrated Life Cycle Management

The Netherlands National Environment Policy Plan sets out quantitative targets for a number of pollutants and waste streams. There are targets for 2010 and are expressed in Table 1 as a percentage reduction from 1985 (or 1980) levels. The analysis proceeded to look at how these targets could be achieved. Three scenarios were examined: a continuation of current policy (I); a very strict emission orientated regime (II) and a package of emission orientated measures together with a more far-reaching change to the pattern of consumption, resource use and waste production. A key element in this more "structural" strategy was a focus on integrated life cycle management (ILCM).

ILCM is a strategy designed to ensure that all the "actors" involved at all stages in the production and consumption of goods and services shape their activities to minimise the use of resources and production of wastes.

To achieve the aims of the Netherlands NEPP and to improve environmental quality to the defined target level of 2010, it will be necessary to meet consumer demand for goods and services in such a way as to minimise the production of waste at all stages of the "life cycle". While waste minimisation at each stage will be an important component of the strategy, ILCM also requires that there is some reshaping in the way that goods and services are supplied to the consumer; and this reshaping necessarily affects each stage in the production chain.

There are two important points. First, the aim is not to limit economic growth. Rather, it is recognised that the cost of add-on pollution control will continue to grow and in the long run could have a greater impact on economic prosperity than refocussing the way that goods and services are supplied. Second, there are numerical targets. In the past, politicians have exhorted industry and consumers to cut waste, increase recycling etc, reduce hazards, use public transport etc; but they have failed to support these exhortations with targets and coherent strategies let alone policies or implementation - in other words, they have failed to create the necessary conditions.

Conditions for Sustainable Development

Table 2 sets out some of the conditions for a concentrated reduction of pollution levels such as those envisaged by the Dutch Plan.

Influencing the market. The choice of resources, goods and services by consumers and producers depends on price, availability and information; producers are influenced in the product design and supply of services by consumer behaviour. Economists will argue that a key component of the ILCM strategy must be pricing: to ensure that the environmental costs are fully taken into account and to ensure that pricing is used (through application of economic instruments) to implement government policy. Improving the flow of information (from producer to consumer) and of education (understanding the environmental implications of certain actions) are also important elements.

Influencing the public sector. It is often forgotten that government is a major provider of goods and services and a major purchaser (consumer) and investor. The way in which for example the public sector establishes its procurement policies and invests in transport infrastructure has a major impact on resource use and waste production. Once again, pricing is an important tool: but it is important that information is available in the decisions that are being taken, and government can influence the market (and pricing) by its procurement policies: if the public sector will only purchase cars with catalytic converters that creates a considerable "base load" market for manufacturers.

"Command and control" restrictions. Market mechanisms alone are unlikely to prove adequate; in certain sectors actions will be required to achieve the aims through restricting the use of certain substances, requiring that certain information is made available, regulating the proportion of a substance in a particular product, limiting waste discharges.

Integration. The conditions need to be such that in each part of the producer-consumer-user chain, the decisions taken are consistent with the overall aim of minimising waste and resource use and delivering goods and services in an environmentally less damaging way.

Categories of Instrument

Based on the above, Table 3 sets out the instruments available to bring about ILCM. The Table also indicates how each type of instrument may be expected to influence each group of actors.

1. **Economic instruments.** These are primarily charges and taxes levied on products or discharges (eg, taxes to make leaded petrol more costly, or charges on discharges to water or air of pollutants); subsidies to encourage certain investments; and deposit refund schemes. They also include tradeable permits.

2. **Command and control.** These include product and discharge standards and restrictions.

3. **Information.** This category includes the provision of information (or the requirement that information is provided) about a particular plant, substance or product. It therefore includes labelling, auditing, environmental impact assessment (EIA).

4. **Liability.** This category includes measures that require the discharger to bear responsibility (and costs) for any damage caused by products or wastes.

5. **Education.** This category is concerned with the general provision of data about the environment, a process or a substance. It therefore includes government information about clean technologies, recycling centres, state of the environment.

EXPERIENCE OF IMPLEMENTATION

I. Economic Instruments

There has been renewed interest in product and waste charges over the past two years in OECD countries and particularly in Europe.

Economic instruments, charges and subsidies can be used:

- to ensure that the full environmental cost is included in the price of goods or services or in cost of waste disposal;
- or, and more pragmatically, to change behaviour by ensuring there is a differential that favours the environmentally less damaging option;
- or to raise money to subsidise environmentally less damaging processes or services (eg transport);

Tradeable permits that have been employed in the US have a more limited role in allowing dischargers adjust at least cost to regulation

There are at present a range of product charges in force in Europe particularly in Scandinavia. In addition there has been extensive use of pollution and waste disposal charges and subsidies in Europe over the past decade: for example in the Netherlands, France and Germany for waste water discharges and there is increasing interest in extending full cost recovery charges for waste disposal to include even the opportunity cost of the facility or wider environmental costs. (eg in California).

There are a number of issues:

- How practical is it to introduce a widespread system of environmental cost accounting to ensure the full costs are paid? This issue is on the agenda in a number of countries and companies but experience is fairly limited.
- In which areas would introducing economic instruments have the greatest effect? How is the level of price required to change behaviour to be determined?. In Sweden it was found that a high

charge was required to achieve a 75% beverage container recovery rate; in the UK a differential of around 5% was sufficient to encourage the use of lead free petrol.

- What are the practical issues?

II Restrictions

Government can of course achieve the more fundamental pollution prevention strategies and goals through regulations restricting or encouraging certain practices. Examples include the following.

Recycling: in Denmark there is legislation requiring that all beverage containers should be returnable; this is supported by a deposit scheme. Government may also regulate to encourage all stages in waste recycling, but in most countries, activity has been limited to exhortation.

Restricting substances. Sweden has taken steps to restrict the industrial use of cadmium in order to reduce the amount that is dispersed in the environment. Similar actions have taken place in Denmark and there is some voluntary action by companies.

Product use. In the US, legislation imposes strict requirements on vehicle manufacturers to ensure that average fuel consumption in their whole production achieves 26 miles per gallon by 1990. Failure to achieve these levels will be met by fines of $50 per car.

But again there are a number of issues:

Why have governments tended not to use restrictions to encourage recycling, limit environmentally hazardous substances from products or restrict waste? These approaches have been used to protect consumer health but with a few exceptions have had limited application where environmental protection or resource use has been the goal.

Are they effective instruments for creating the conditions for long-term pollution prevention? Or are they too interventionist, potentially distorting the market? Are they difficult to design without protecting one part of the environment at the expense of the other?

Where are the priorities where this form of instrument should be used? What are the practical issues?

III Liability

Liability may also be seen as a market mechanism insofar as it brings the responsibility for the damage caused by products, processes or waste streams into the financial calculations of the producer or consumer: it introduces a need to minimise risks, wastes and discharges for financial reasons.

The Superfund legislation in the United States imposes a strict liability upon firms that have deposited wastes on sites where subsequently clean-up is required. An important issue is that evidence of use of the site imposes a liability on the firm; and that liability might be for the full clean-up cost. In other words, the burden of proof is shifted: the regulator no longer has to prove damage has occurred or the proportion of damage caused by the discharger; rather, there is a strict "joint and several" liability.

Also in the United States, the Environmental Clean-up Responsibility Act (ECRA) of New Jersey requires firms to notify any event likely to cause contamination. Firms are also required to prove the applicability or non-applicability of clean-up responsibility when they are selling a major portion of the company.

The EC is also considering extending liability to waste producers so that they have strict liability up to the point of final disposal.

The key issue here is:

How successful has imposition of liabilities been in terms of altering producer and consumer practices? Could the schemes be better focused?

IV Information

Information is in part a "market mechanism" insofar as full information about environmental implications of products will allow the consumer to make an informed choice when purchasing. Information is also an important tool in terms of providing members of the local community with information about the waste discharge from factories or the risks associated with materials stored on the premises.

Product information. Environmental labelling is under consideration in a number of EC countries, Japan, Canada and non-EC Scandinavia. For example, the German Blue Angel eco-labelling scheme covers 57 product categories but is not compulsory. Government regulation sets a frame for the standards required to be eligible for such awards but application by manufacturers for blue label awards is voluntary. Government procurement policies stipulate that public authorities should use Blue Angel products where these are available. Similarly the US Conservation Act sets energy efficiency requirements and standards for 13 categories of major domestic appliance: standard test procedures are laid down and appliance labelling is required to show energy efficiency or annual cost of operation of the machine.

Voluntary auditing and information disclosure. A number of companies audit their own activities in order to identify potential environmental risks, opportunities for waste minimisation etc. Such practices are increasingly commonplace amongst major multinationals.

Environmental Impact Assessment. (EIA) for developments and products. EIA is an information tool: it allows the planning authority and community to understand the environmental implications of a proposed new development and provides the opportunity for re-shaping at an early stage. Environmental assessments are also under consideration for products: in Sweden an attempt is being made to develop an approach to examine raw materials, processing, use and waste for a range of products.

Compulsory disclosure. Organisations may be required by law to provide information on potentially environmentally damaging substances stored or released. The EC Seveso Directive requires companies to make information available about certain categories of substance stored on site. In the US, the Toxic Release Inventory requires manufacturers to provide the EPA with information on routine or chemical releases to air, water, land or sewage for over 300 listed potentially hazardous chemicals. The public has full access to the information.

There are a number of issues.

Does environmental labelling work? What are the key elements in making it work: how are criteria established? Should labels only be given if all aspects of the product and packaging are "environmentally friendly"? How is the scheme audited?

How can company auditing be encouraged? Should disclosure of the results be made compulsory? How can auditors be trained and a code of conduct established?

What evidence is there that providing information about waste and toxic releases has a feedback in terms of altering the behaviour of the company? How can such schemes be shaped? Should they be tieo into auditing?

How valuable are product audits or product assessments? Can the approaches currently being considered be linked into labelling? How again does one establish the criteria? What links to other instruments might be required?

V Education

Education has been a major tool in terms of encouraging changes in producer and consumer behaviour.

To a large extent it has been **government inspired.** For example a number of OECD governments have provided extensive information on recycling, waste minimisation, energy conservation and on the use of different types of resources and products with information on the environmental consequences.

Environmental pressure groups have also had an impact. The tropical hardwoods campaign in Europe is an example. Environmental groups actively lobbied government and international agencies to change hardwood forest management practices; they also lobbied the retailers of tropical hardwood products and approached consumers through publications such as the "Good Wood Guide" in the UK. Over 200 retailers or specifiers (eg architects) for furniture and wood fittings agreed to a statement that they would only sell tropical hardwood products from sustainable sources. A number of Local Authorities made a similar commitment.

There are also **investor implications.** A group in the US has established a set of principles called the "Valdez Principles". Companies that wish to be considered environmentally sound (and as such ones that ethical investors would wish to support) are being asked to agree to these principles: they include voluntary auditing and disclosure of the results. The availability of such information would educate the investors.

There are a number of relevant issues.

How effective are government information campaigns? Are they undertaken because they are inexpensive and give the impression that action is being taken? Do they achieve results? Should they be tied to other instruments?

Are environmental pressure groups an important element in providing information to shape public opinion and the choice of environmentally less damaging approaches? Is there evidence for this? Should such campaigns receive financial support from government?

CONCLUDING COMMENTS

Overall it can be seen that "creating the conditions" involves a different response by government from that which has traditionally been the pattern over the past two decades. In the sector of minimising waste and resource use there has been a tendency for government action to focus on new technologies: providing R&D subsidies, information exchanges, technology transfer etc. While these may be important elements, they should be seen as actions that will be required to relieve particular bottlenecks rather than priorities in themselves.

In general there is therefore the need to focus on (i) creating the conditions under which all the many individual decision makers implement environmentally less damaging initiatives; (ii) ensuring that targets are met for particular target sectors and (iii) identifying for any one country the international and trade implications.

The paper has examined those instruments that can create the necessary conditions within which environmentally less damaging decisions will come to be taken. There is clearly a need to provide a consistent framework that allows potential environmental damage to be taken into account and, in general, to avoid a piecemeal approach to environmental management planning.

TABLE 1
Netherlands Plan. Targets for 2010

	Target	% reduction achieved by Scenarios (3) I	II	III
SO2 (1)	to @ 10%	-50	-75	-90
Nox (1)	to @ 10%	-10	-60	-80
NH3 (1)	to @ 10%	-33	-70	-80
Hydrocarbons (2)	to @ 20%	-20	-70	-80
Discharges to Rhine and North Sea (2)	to @ 20%	-50	-75	-90
North Sea waste (2) to @ 10%		0	-50	-90

(1) 1980 is base year

(2) 1985 is base year

(3) Scenarios

I Continue current pollution policy control (Cost 1.9% GDP)

II Maximum utilisation of currently available emission orientated measures (Cost 3% GDP)

III A package: emission-orientated and "structural" source orientated (Cost 4% GDP net)

Costs assume other countries do not take the same measures as the Netherlands.

Derived from: National Environmental Policy Plan, Netherlands Government, 1989.

TABLE 2
Role of actors in Pollution Prevention

	OBJECTIVE	DECISION FACTORS
CONSUMERS:		Influenced by:
	Choice of environmentally less damaging products and services	Pricing (economic instruments)
	Use products and services in an environmentally less damaging fashion	Product availability (regulations).
	Recycle more of waste stream.	Information to aid environmentally less damaging choices. (regulation information and education)
PRODUCERS:		Influenced by:
	Design and make available environmentally less damaging products services.	Consumer choice. Risks, responsibilities and potential claims (liabilities, information, education)
	Develop and install environmentally less damaging processes	Availability and price of resources (regulations, economic instruments)
	Invest in R&D designed to identify environmentally less damaging products and processes.	Restrictions and cost of waste discharges and attractiveness of secondary materials market (regulations, economic instruments)
		Encouragement to install new processes or undertake R&D, (economic instruments)
INVESTORS:		Influenced by:
	Finance available only to producers that are committed to environmentally less damaging processes, products, services.	Ethical concerns (education). Longterm profit motive (education information)
MEDIA:		Influenced by:
	Provide education on environmentally less damaging processes, products, services.	Ethical concerns (education). Longterm profit motive (market forces)

TABLE 3
Instruments for implementing ILCM. Examples relating to different actors.

Instruments	Consumers	Producers	Investors
Economic instruments (Taxes, other subsidies)	Influence product pricing to encourage purchase charges, and use of environmentally less damaging products (eg lead in petrol). Encourage recycling of beverage containers.	Encourage use of cleaner processes, (eg German waste water charges) or installation of cleaner processes (eg subsidy schemes operating in some EC countries). Encourage R & D into cleaner processes.	Possibility of tax incentives for "Green" investment funds.
Command and Control	Regulate type of product sold (eg hazardous substances, vehicles, eg USA CAFE or require recycling (eg beverage containers) or way product is used (speed limit in USA).	Controls over discharges, wastes, environmental standards etc. Controls over use of resources, types of process etc (eg Cadmium controls). Establish product standards (length of life, recycled content etc) and link these to procurement policies.	
Information	Requirement that information be supplied to consumer (or encourage voluntary measures) (eg Blue Label).	Requirement that information on all discharges released to public domain (eg USA Toxic Release Inventory).	Possibility of requirement that companies should provide environmental audit information (Valdez Principles).
Liability	Requirement that consumers (users) should be responsible for full cost of any environmental damage.	Requirement that producers bear full responsibility of cost of damage caused by products or processes or are fully liable for any incident where they may have been partly responsible (ECRA,).	Investors take account of potential liabilities when providing finance to producers.
Education	Increases ability of consumers to make an informed choice (eg Tropical Hardwood Campaign, Hewlett Packard, Agfa).	Increases producer awareness of risks, liabilities and and opportunities for improvement, also availability of new technologies and need for waste minimisation.	Increases investor awareness.

TECHNICAL ASSISTANCE TOOLS AND APPROACHES
WASTE REDUCTION INCENTIVES AND BARRIERS: THE FLORIDA EXPERIENCE

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Waste reduction is an idea whose time has come. More accurately, it is an idea whose time has returned. In a less profligate age it was unthinkable to waste raw materials and energy because they were in such short supply. The discovery of the planet's liquid fuel reserves gradually changed our attitudes toward the way we made and used products. With very cheap energy and unregulated disposal of wastes, the consequences of inefficient energy use and unsafe waste disposal were effectively passed on to future generations. It was as if we had found a savings account passbook, in the form of petroleum reserves, lying on the ground. We went to the bank and found we could make withdrawals. What we didn't realize then was that the function of that savings account was to get the human race through a transition period during which a self-sustaining industrial ecosystem would need to be invented. By the 1960's it had become evident to some that we would never close the loop on this ecosystem and quite possibly poison ourselves out of existence if the way wastes were handled did not change. The Environmental Protection Agency and the Department of Environmental Regulation were founded to address this problem. Regulating the treatment of specific wastes in specific media (air, land and water) and permitting their disposal was the first step in a process of making industry and through it, society, responsible for the consequences of the way products are designed, manufactured, used and discarded.

As regulations became stricter and the number of regulated wastes expanded, disposal costs rose and more of the costs that had formerly been transferred to the future were brought back into the present. The regulatory framework can be thought of as functioning to simulate scarcity of energy and raw materials, thereby encouraging waste reduction. The non-regulatory Waste Reduction Assistance Program (WRAP) in the State of Florida's Department of Environmental Regulation was created to assist the regulatory side of the Agency by encouraging voluntary waste reduction. The program's goal is to reduce the flow of all wastes into all media by:

1. Changing industries' attitude toward waste
2. Connecting industry to waste reduction tools and

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1. Changing industries' attitude toward waste
2. Connecting industry to waste reduction tools and

3. Helping make waste reduction a permanent part of the corporate culture.

For this program to be successful it became apparent early on that it would be necessary to examine the incentives for and barriers to waste reduction. After all, if waste reduction is such a great idea, why isn't it already happening? Let us examine the tasks mentioned above in light of the forces that assist and impede their accomplishment.

Program engineers try to change industries' attitude toward wastes by showing them how to look upstream from the "end of the pipe" toward the sources of waste. A new hierarchy of waste management is taught:

1. Source Reduction
2. In-plant recycling
3. Out-of-plant recycling
4. Treatment to detoxify waste
5. Disposal as a last resort.

Concentrating on treatment, the "end of the pipe", fosters the attitude that waste costs are merely a part of doing business. Waste costs become part of the budget and someone is assigned to manage compliance and keep up with changes in regulations. Once that is accomplished, the system is thought to be in control and that is the end of their effort. What were supposed to be incentives for waste reduction, increasing disposal costs and regulations, have become barriers. Looking upstream from the end of the pipe on the other hand encourages industry to take control of the source of the waste, not merely its treatment.

Back at the source, the nature of the true costs of waste becomes more apparent. For example, a Florida company that paints aluminum asked for help dealing with their paint waste. They electrostatically apply thermosetting high-solids coatings (paints that remain liquid until heated to over 300°F) with about 95% efficiency, which is very close to state-of-the-art. They paint so much, however, that they have over 10,000 gallons of oversprayed paint and clean-up solvent per year. Disposal costs are about $30,000/year which was a concern of the paint manager at the company. The visiting Waste Reduction Assistance Program engineer pointed out that the waste they were paying $30,000 to throw out contained over $150,000 in raw materials in the form of paint and solvent. (Typically, 75% of the savings from waste reduction come from raw material cost savings.) The real cost of waste is more than $180,000 per year. It would take an additional $3.6 million in sales to generate the same bottom-line balance-sheet effect as eliminating this waste cost. This potential cost savings is the single most powerful incentive for waste reduction. Why then wouldn't a company leap at the chance to save $180,000 per year?

Examining a list of barriers to waste reduction will give us some possible reasons. We've already mentioned three: there is a budget for waste, the company is complying with all regulations and the system is working. "If it ain't broke, don't fix it." We can add to those the following:

1. The generally short-term economic focus of American industry.
2. Although there is a budget for waste, there is no budget for pollution prevention. (In our own lives, for example, most of us have health insurance, but far fewer have a budget for the prevention of health problems.)
3. If implementation of the waste reduction idea requires a permit, companies are very reluctant to pursue it.
4. Competition for resources within the company.
5. Fear of failure, especially with a new technology.
6. Concerns for product quality.

Let us assume that the Waste Reduction Assistance Program has accomplished its second task and found an in-plant-recycling waste reduction solution to this company's problem and that the permit question has been resolved to the Department of Environmental Regulation's satisfaction. Further assume that the capital cost is $25,000 and the operating costs are $0.25 per gallon recycled. The payback period for this solution would therefore be about 7 weeks. This should overcome the short-term-focus barrier and make it competitive for company resources. The technology is not very complex and in its general form has been applied elsewhere. This leaves us with the last barrier: concerns about product quality.

The long-term survival of a company depends upon producing consistently high-quality products. Any changes that may affect that quality are examined very closely before being implemented. The collection, filtration and reformulation of thermosetting paints is the way some office furniture manufacturers handle their overspray paint. This Florida company, however, paints parts for exterior use and will have to be convinced by testing or example that the coating will not degrade five years from now as a result of the recycling process. In the final analysis someone must be willing to take the risk of trying any new idea. There are a number of incentives whose benefits are not easily quantified, but which can encourage companies to take risks and try new processes.

If a waste reduction idea could totally eliminate a class of waste, the cradle to grave responsibilities for that waste disappears with it. Unknown, off-balance-sheet costs such as those associated with future Superfund cleanups or other long-term liability problems associated with having produced a waste are perceived as risk by the securities markets. The greater the perceived risk the lower the price of a company's stock. This gets the attention of Chief Executive Officers and shareholders. Another non-quantifiable incentive is getting off the top of the list of generators of hazardous waste or air toxics. No one can say exactly what that is worth, but our experience shows it to be a powerful incentive. Being an environmentally responsible business is becoming more important to a company's survival with each passing day.

A waste reduction solution which lowers health risks for employees has a better chance of being implemented than one that doesn't. This incentive may prevail in cases where the power of the cost savings incentive is weakened by the structure of an industry. For example, some regulated industries and the defense industry have incentives to merely pass waste costs on to customers and/or taxpayers. Let us examine the Waste Reduction Assistance Program's second task, which is to connect companies to waste reduction tools, with an example that illustrates some of these incentives.

Some waste reduction opportunities are easier to implement because the necessary equipment already exists. A Florida chemical repackager is installing dry-disconnect hoses and changing a piping manifold so that solvent cleanup between batches becomes unnecessary. Other opportunities involve operational changes that make a worker's job easier and therefore have a good chance of becoming standard practice. In some cases, however, a solution is apparent but the equipment to implement that solution does not exist. In this case, connecting industries to waste reduction tools means a search for someone willing to build a new type of equipment.

Vapor degreasing is a cleaning technique used to prepare parts for electroplating or painting. It involves placing a room temperature part into hot solvent vapor. As the vapor condenses it washes off any contaminants. The more common solvents used are halogenated hydrocarbons such as perchloroethylene, trichloroethylene, 1,1,1-trichloroethane, dichloromethane and Freon 113. Research is being done on replacing these toxic smog-creating or ozone-depleting cleaners. There are, however, a few intractable cleaning problems that remain, so that this cleaning method will likely be around for at least another 5 years. Quite a few of these cleaners have been seen in the course of the more than fifty on-site assessments Program engineers have performed. Most of them are losing substantial amounts of solvent to the atmosphere. Fugitive and stack emission for 1988 of these 5 chemicals, from just those Florida companies reporting under SARA Title III regulations, amounted to more than 8 million pounds. The losses are a direct result of the way degreasers are designed and operated. As presently constructed the lids must remain open while parts are being degreased. Substantial air flows are required in the work place both for health and comfort reasons. This air flow blows solvent out of the degreaser whenever it is open. In addition to these losses, operators can cause solvent losses by moving parts in and out of the dergreaser faster than one foot every six seconds. Given Florida's climate, which makes wearing a gas mask uncomfortable and the fact that these degreasers operate at over 170 degrees Fahrenheit, operators try to spend as little time as possible standing over them.

The solution seems to be a split lid which can be closed after the part is inserted and a programmable controller for both the lid and the parts winch. This would assure that the lid was closed as much as possible, prevent losses due to rapid part movement and get the operator away from the source of solvent when the lid is briefly open. The problem is that no one seems to make such a device. Program engineers have found two cases where lids were brought under control and in both solvent losses fell dramatically. At Lufthansa's rebuild facility in Hamburg, Germany losses to the air went from 75 tons/year to 2 tons/year when a very elaborate degreasing facility was constructed. On a much smaller degreaser in America, strict manual control of a split lid reduced solvent losses from 48 drums/year to 1 drum/year. The search for a vendor of retrofit equipment of this nature is continuing. One of the program's clients, an aircraft component rebuilder, loses $75,000 of solvent/year from one degreaser! This would seem to be a powerful economic incentive for purchasing such waste-reduction equipment. The rebuilding of airplane components, however, is a regulated industry. Other rebuilders experience similar solvent losses and costs. The ability to pass these costs on to the airlines (and passengers) makes the expense and effort of implementing this waste reduction solution less attractive. Similar forces are at work throughout the defense industry. The more powerful incentives for this company are the fact that they are at the top of the local polluter list and that it offers the opportunity to drastically reduce worker exposure to a hazardous chemical. Being the top polluter in an area makes company officials very uncomfortable. The unknown future costs of worker health problems, like the unknown future costs associated with cradle-to-grave responsibility for wastes, subject a corporation to a risk that it cannot predict accurately. Good business practice dictates that such risks should be minimized.

The third and final task of the program is to help make a waste reduction program a permanent part of a corporation's culture. The biggest barrier to accomplishing this is the fact that everyone already has a full time job. The environmental manager is especially busy. Typically, this person oversees waste disposal, worker health and safety, all waste reporting, training of workers in waste handling and safety and frequently also oversees quality control and instrument calibration. The possibility of reducing one of the company's waste streams is an attractive incentive, but where is the time to do it going to come from? One can picture waste reduction opportunities as fruit on a tree. What WRAP engineers are trying to do is find a nice piece of low-hanging fruit, put it in the appropriate person's hand, help them carry it to upper management and say, "Look what we could do if you would commit some resources to waste reduction." The successful completion of that project must be the stimulus for a company-wide policy of waste reduction with top-management commitment and the involvement of every worker. Waste reduction must become part of what a company does every day for it to be successful. When this happens, the time and money necessary to accomplish waste reduction will become available.

The Waste Reduction Assistance Program has been fully staffed for a little over 6 months. It is therefore too early to say how successful the program will be in accomplishing this last task. Hundreds of examples from all over the country indicate that success at waste reduction is an infective process. One Florida client, having had success with his first waste reduction project, finds that whenever he walks though his plant he now thinks not of how many parts are being made, but of how he could reduce each waste stream. The benefits of waste reduction so outweigh the costs of implementation, the incentives for it are so much more powerful than the barriers to it that, once begun, waste reduction becomes an integral part of a company's survival strategy. Every time that happens, we take another step toward creating the closed loop industrial ecosystem necessary for our long-term survival.

UNDERGROUND COAL GASIFICATION: GROUNDWATER CONTAMINATION CAN BE PREVENTED

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ABSTRACT

The prime environmental concern associated with underground coal gasification (UCG) is the potential for groundwater contamination. Previous UCG field tests have impacted groundwater quality. With the support of the Gas Research Institute (GRI) and the U.S. Department of Energy (DOE), an environmental program was developed to address contamination of groundwater resulting from UCG operations. As a result of this program, a clean cavity concept was devised to reduce the generation, deposition, and transport of contaminants associated with UCG operations. Restoration procedures and operational constraints devised from this concept were incorporated into the operational plans for the Rocky Mountain 1 (RM1) UCG field test. Test results show that the restoration procedures and operational constraints successfully reduced impact to groundwater quality resulting from UCG operations at the RM1 site.

INTRODUCTION

Underground coal gasification (UCG) has the potential to significantly increase the usable energy resources of the United States by developing coal reserves that are too deep or too thin to be economically mined with conventional techniques. UCG recovers the energy of a coal seam as a gaseous fuel through a combination of in situ coal drying, pyrolysis, and gasification processes. Major constituents of the gas include steam, carbon dioxide (CO_2), carbon monoxide (CO), hydrogen (H_2), and methane (CH_4). Some hydrogen sulfide (H_2S) is also found in the gas. This gas can be used as a fuel or as a feedstock for producing liquid (e.g. methanol) and gas products. Up to 90 percent of the heating value of the coal can be recovered as combustible energy and sensible heat. Due to the in situ nature of the process, minimal surface disruption and reduced capital costs relative to surface coal gasification are achieved.

The UCG process is a relatively simple process and, in its most basic configuration, consists of two vertical process wells in the coal (Figure 1). Most commonly, the methods used to create the permeability necessary for fluid flow between the vertical well pair are reverse combustion, horizontal drilling, or a combination of the two. Reverse combustion consists of starting a fire in the coal seam at the base of one well and injecting high pressure air in the other well. The air permeates though the coal and intersects the combustion zone at the base of the first well. The reverse combustion zone follows the oxygen source back to the injection well forming a highly permeable charred channel between the wells. In horizontal drilling, a horizontal well is drilled in the coal seam to intersect the vertical wells. Once conditions promoting fluid flow between the wells have been established, gasification of the coal is initiated by injecting oxygen or air.

UCG has been field tested at a number of sites in the United States. Most of this testing occurred in Wyoming during the 1970s, and some of these tests contaminated the local groundwater. Local groundwater contamination resulted in the perception that the UCG process was inherently detrimental to the environment, and concern resulted about the environmental acceptability of the process. Because of the potential benefit of the UCG process to the energy independence of this country, the Gas Research Institute (GRI) and the U.S. Department of Energy (DOE) initiated a program to address the environmental issues associated with the process as part of the Rocky Mountain 1 (RM1) UCG test program near Hanna, Wyoming.

TECHNICAL APPROACH

The initial focus of the environmental program was to evaluate data from previous UCG tests to better understand the mechanisms of UCG-induced groundwater contamination. The hydrogeology of old test sites and operational histories of these tests were reviewed and evaluated.

Subsequently, an approach was developed and applied through which the basic mechanisms of UCG groundwater contaminant generation, deposition, and transport were investigated at a laboratory scale. The objectives of this research to evaluate the potential impact of the UCG process on local groundwater quality and to develop control technology for reducing impacts to groundwater from UCG operations. A series of bench-scale UCG simulation experiments were conducted to evaluate the interaction of the gasification process with the hydrogeologic environment. The environmental control technology developed was demonstrated as a part of a UCG field demonstration conducted near Hanna, Wyoming.

The field test, designated RM1 UCG test, was conducted during the fall of 1987 and the spring of 1988. Two different UCG configurations were simultaneously tested in separate process modules. They were the Elongated Linked Well (ELW) configuration and the Controlled Retracting Injection Point (CRIP) configuration. Details of the test are presented in the literature (United Engineers and Constructors Inc., Stearns-Roger Division 1989). An extensive environmental program was conducted as part of this test to evaluate the effectiveness of the bench-scale-derived control technology in a commercial UCG facility. This program consisted of the following components:

- Site Characterization
- Test Monitoring
- Groundwater Restoration
- Restoration Monitoring

The site was characterized to evaluate the condition of the pregasification hydrogeologic environment at the test site and included an extensive evaluation of the baseline groundwater quality. Groundwater quality and physical parameters were monitored during the test to determine changes resulting from UCG operations and to determine the effectiveness of the posttest environmental control technology. After the completion of UCG operations, the UCG cavity was cleaned of potential contaminants and the affected groundwater was removed, treated, and discharged to the surface. Long-term groundwater monitoring continued after UCG operations were completed and will continue through 1992. This report reviews the results of the environmental control technology demonstrated during the RM1 UCG test by summarizing the groundwater quality data for the test site. Further details related to changes in the hydrology and groundwater quality at the UCG test site and the importance of these changes are reported by Beaver et al. (1988) and Moody (in press).

RESULTS AND DISCUSSIONS

ENVIRONMENTAL EVALUATION OF PREVIOUS UCG TESTS

A review of previous UCG tests conducted in the United States showed that selection of a UCG test site in which the coal seam is not severely fractured or faulted and in which the coal seam is hydrologically isolated from near-by aquifiers is beneficial for reducing potential groundwater contamination and associated impacts. Hydrologic isolation from near-by aquifiers confines the gasification products within the gasification cavity, which is important for reducing groundwater contamination from the process. The containment of gasification products within the gasification cavity depends on the physical properties of the coal seam and boundary strata (e.g. permeability). Other important factors to consider in the location of the UCG operating facility are thick competent boundary strata separating the coal seam and aquifiers, the existing water quality and use of potentially affected aquifiers, and a minimum of structural deformations (e.g. faults).

The Hoe Creek and Rawlins UCG field sites are examples of the importance of site selection for reducing the potential for groundwater contamination. The Hoe Creek site is located near Gillette, Wyoming, and three UCG field tests were conducted at the site from 1976 through 1979. The target coal seam was at a depth ranging from 160 to 200 feet from the surface. The coal seam was a relatively permeable aquifier overlain by poorly consolidated overburden containing several other water-bearing zones. Extensive subsurface subsidence into the cavity that was created during the tests caused as much as 20 percent of the total produced gas to flow from the UCG cavity into the local strata. The gas loss contaminated the near-by aquifiers with benzene and phenols (Barrash et al. 1988).

The hydrogeologic evaluation of the Rawlins UCG test site near Rawlins, Wyoming, indicated that the coal seam had low permeability with structurally strong boundary strata and no overlaying aquifiers. Two large UCG field tests were conducted in 1979 and 1981. Because of the hydrogeologic conditions at the site, little impact to the local groundwater systems was detected.

All of the Hoe Creek and Rawlins UCG tests were conducted with UCG reactor pressures higher than the hydrologic pressure of the coal seam aquifier being gasified. In the Hoe Creek tests, the high permeability of the coal seam and unconsolidated nature of the overburden created conditions that resulted in contamination. In the Rawlins UCG tests, the low permeability of the coal seam and the consolidated nature of the overburden created conditions that helped prevent contamination. These two test series illustrate that selection of a UCG site with favorable reservior conditions, similar to the Rawlins test site, can reduce the potential for impacts from the process on the local groundwater quality.

However, from the UCG-field test review, we found that the groundwater could become significantly contaminated after active gasification was completed. After gasification operations, a large mass of hot rubble exists in the gasification cavity (Figure 1). The temperature of this rubble can exceed 2500°F. Heat transfer from the rubble into the adjacent coal continues and results in continued coal pyrolysis with corresponding generation of pyrolysis products. Laboratory research confirmed that it is these pyrolysis products are the source of potential groundwater contaminants (Boysen et al. 1988). If these pyrolysis products are not removed from the subsurface environment, they can contaminate the groundwater. The environmental evaluation of previous UCG testing led to the development of a theory that addressed the fundamental causes of UCG-related groundwater contamination. With this understanding of the mechanisms for UCG related groundwater contamination, it was hypothesized that contamination of groundwater can be minimized, even in sites with unfavorable hydrologic and geologic conditions. Two simple operational constraints implemented during UCG will reduce possible contamination of groundwater: gas loss from the UCG cavity to the surrounding strata must be minimized, and pyrolysis products generated after gasification must be removed from the underground system before they can solublize in local groundwater. The clean cavern concept was developed and refined in a laboratory program to develop control technologies to reduce UCG-related impact on local groundwater (Boysen et al. 1988).

CONTAMINANT CONTROL METHODS DEVELOPMENT

The clean cavern concept for UCG requires operators to (1) contain UCG products within the cavity and process piping, (2) evacuate postgasification products (pyrolysis products) from the UCG cavity, (3) cool the rubble in the gasification cavity, and (4) remove affected groundwater for treatment, if required. UCG operating procedures were developed to accomplish these objectives and were evaluated in a laboratory simulation program.

Results of the literature survey previously discussed illustrate the importance of proper site selection to reduce the environmental impact of UCG. Further, results of the laboratory simulation program show that groundwater contamination can be significantly reduced by applying UCG operational constraints and the proper gasification termination procedures (Boysen et al. 1988). The most important aspect of UCG groundwater contamination control is the constraint on cavity pressure during and after UCG operations. Cavity pressure that is greater than the hydrologic pressure of the coal seam can push UCG product gases and condensibles out into adjacent water-bearing strata contaminating the aquifier. The Hoe Creek test is an example of contamination that resulted from high operating pressures. However, after gasification operations are terminated, the high cavity pressure also needs to be constrained. The residual heat in the UCG cavity will convert groundwater flowing into the UCG cavity into steam. If a gasification cavity is not vented after gasification operations, the UCG cavity pressure will increase. The pressure can eventually exceed opposing forces (permeability and hydrologic pressure) permitting cavity gases to flow into the surrounding strata.

In addition to reducing the potential for gas flow into surrounding strata, cavity venting promotes water influx into the gasification cavity. Influxing groundwater enhances the cooling of and contaminant removal from the cavity walls and rubble. Further, the creation of conditions to promote water influx into the UCG cavity after gasification allows UCG-contaminated groundwater to be removed from the underground system to the surface where it can be treated for use, disposal, or reinjection.

Other gasification termination procedures can reduce groundwater contamination. Flushing the cavity with steam will accelerate cooling while stripping contaminants from the cavity walls and rubble. Monitoring groundwater levels in and around a gasification cavity will provide indications that groundwater is about to flow out of the gasification cavity. Any affected water in the cavity can be removed before it can impact adjacent water-bearing zones.

ROCKY MOUNTAIN 1 (RM1) UCG TEST

The contaminant control methods developed and evaluated in the laboratory were incorporated into the operation plans of the RM1 UCG test as a comprehensive environmental program designed to demonstrate and evaluate these methods. The planned environmental program included:

- Maintenance of cavity pressure below hydrostatic pressure of the coal seam aquifier to reduce the potential for gas loss during operation
- Venting and flushing of the UCG cavities with steam after operations to maintain reduced cavity pressures, remove potential groundwater contaminants from the cavities, ensure the collection and containment of affected groundwater, reduce cavity rubble temperature, and strip contaminants from the cavity walls and rubble
- Monitoring groundwater flow gradients to assure containment of affected groundwater in the gasification cavities until this water can be removed by pumping
- Removal, treatment, and discharge of affected groundwater from gasification cavities before the water could migrate away from the cavities and impact unaffected regions of the coal seam aquifier

RM1 Site Selection and Characterization

The RM1 site was located adjacent to the old Hanna UCG test site near Hanna, Wyoming. The RM1 site possessed good hydrogeologic characteristics for UCG operations based on test data from the previous Hanna tests. The target coal seam (Hanna #1) is approximately 360 feet deep at the RM1 site. It is approximately 30 feet thick and is classified as a high volatile C bituminous coal (Mason et al. 1987).

Preoperation site characterization revealed both desirable and undesirable features. The boundary strata consisted of competent (strong) consolidated shales and sandstones. In addition, the nearest aquifier above the coal seam was favorably located more than 100 feet above the top of the coal seam. However, hydrogeologic evaluation of the coal seam aquifier also revealed that the coal seam contained zones of relatively high permeability due to fractures and there were also indications of structural deformities across the site. This suggested that tight constraints on the cavity pressures needed to be maintained during and after UCG operations to prevent gas flow out of the UCG cavities and into the surrounding strata. However, the location of the overlaying aquifiers at the site and competent overburden suggested that any flow out of the cavities would be confined in the coal seam (Mason et al. 1987).

The pregasification groundwater quality (baseline) and hydrology were also evaluated to detect changes in characteristics during and after gasification. Groundwater quality and hydrostatic levels were monitored by using a series of monitoring wells (Figure 2) installed before gasification operations (Mason et al. 1987).

Test Monitoring

Gasification operations were initiated on November 17, 1987, and were completed on February 26, 1988. Two cavities were created from the dual-module operation. The approximate locations of the cavities are shown in Figure 2. The monitoring wells were sampled approximately every ten days during the gasification, and samples were analyzed for a number of chemical constituents that could be introduce into the groundwater as a result of UCG operations. These included phenols, ammonia, total organic carbon (TOC), total dissolved solids (TDS), boron, and cyanide.

During initial UCG operations, some difficulties were experienced that raised the cavity operating pressures above the hydrostatic pressure of the coal seam. Based on data collected from the monitor wells, field observations suggested that the high operating pressures caused UCG gases to flow from the cavities into the surrounding coal seam. This gas flow was toward the southwest, toward well TW-18 (Figure 2). As a result of the gas flow from the UCG cavities, a number of the monitoring wells in the southwest area became pressurized and could not be monitored. Operating pressures were subsequently reduced. This stopped the gas migration, recovered some portion of the gas that had migrated away from the cavity, and depressurized the coal seam near the monitoring wells. As a result of the UCG gas flow into the surrounding coal seam, TOC and TDS concentrations were elevated in the groundwater samples from the monitoring wells to the southwest of the test area. In addition, the groundwater pH in this area was reduced from approximately 8 to approximately 6 due to dissolution of carbon dioxide from the UCG gas. The increase in TOC and TDS probably resulted from the change in dissolution characteristics of the groundwater resulting from the pH change (Moody et al. in press).

Following this short term high-pressure event, UCG cavity pressures were successfully maintained at less than the hydrostatic pressure in the coal seam for the remainder of the test, and gas flow out of the UCG cavity and into the coal seam was stopped.

Postgasification Venting, Flushing, and Cooling of the Cavities

After the completion of the UCG test, the cavities were vented for over 100 days, to flush the cavities, steam was injected into each cavity for 10 days. Vented gases were monitored for flow volume and composition. The amounts of potential contaminants produced during the venting and flushing operations are listed in Table 1 for both process modules. If these contaminants had not been produced from the underground system but had instead been allowed to solublize in the local groundwater, the impact of the RM1 test on the local groundwater quality would have been much worse than it actually was (Boysen et al. 1988).

TABLE 1. RM1 VENT AND FLUSH CONTAMINANT PRODUCTION

Constituent	ELW Module	CRIP Module
Phenols, kg	207	328
Total Organic Carbon, kg	974	666
Sulfide, kg	171	368
Sulfate, kg	103	114
Ammonia, kg	969	1209
Arsenic, g	14	60
Boron, g	356	186

Groundwater Pumping, Treatment, and Discharge

A minimum of two cavity pumpouts and associated groundwater treatments were required to comply with RM1 state environmental permit requirements. The amount of water to be removed from the cavities during pumpout was based on estimated cavity volumes or physical indications that all the cavity water has been removed. The two pumpouts and treatments have been successfully completed.

The first pumpout and treatment was performed from August 25 through September 20, 1988. Approximately 2,100,000 gallons of water was pumped to the surface from the two cavities. This represents approximately 115 percent of the calculated cavity void volume (1,800,000 gallons). The calculated cavity void volume is based on the coal consumed minus the estimated ash volume.

Table 2 lists baseline concentration ranges of the coal seam groundwater for chemical constituents that are normally associated with UCG contaminated groundwater. These values are compared with values for the combined cavity waters at the beginning and end of the pumping. Boron and phenols were the only constituents that were significantly elevated above baseline concentration at the beginning of the pumping. However, in these and in all other cases, the concentration of the constituents decreased as the groundwater was removed from the cavities, indicating that the UCG-affected groundwater was successfully removed after UCG operations. In summary, the water quality was good before pumping, relative to baseline conditions, and improved during pumping. Details of the first cavity water pumping, treatment, and discharge are presented by Covell and Speight (1989).

TABLE 2. CHEMICAL CONSTITUENTS IN CAVITY WATER--FIRST TREATMENT

Constituent	Baseline Range, mg/L	8/25/88, mg/L	9/20/88, mg/L
Ammonia	2.4-7.9	10.4	6.4
Boron	<0.010-0.037	1.97	0.387
Phenols	<0.020	0.760	0.021
TDS	1,360-2,750	2,710	2,160
TOC	11-45	30	27

The second pumping and treatment was initiated when groundwater monitoring data showed that the cavities had again filled with groundwater. This pumping was conducted from July 31 through August 15, 1989. Approximately 1,570,000 gallons of cavity water was pumped from the two cavities. Pumping was terminated when all water was evacuated from the cavities and both submersible pumps lost suction.

Table 3 lists the concentration of the monitored constituents at the beginning and end of the second pumping. The baseline concentration ranges are also lists for comparison. The groundwater quality in the cavities before the pumpout was at or near baseline quality except for boron. The second pumpout further reduced the concentrations of the constituents except for TOC, which increased minimally. Subsequent groundwater monitoring data show that the water quality in the cavities remained near baseline quality. Further restoration efforts probably will not be necessary.

TABLE 3. CHEMICAL CONSTITUENTS IN CAVITY WATER--SECOND TREATMENT

Constituent	Baseline Range, mg/L	7/31/89, mg/L	8/15/89, mg/L
Ammonia	2.4-7.9	9.8	7.9
Boron	<0.010-0.037	1.30	0.64
Phenols	<0.020	<0.020	<0.020
TDS	1,360-2,750	2,890	2,280
TOC	11-45	17	22

Site Conditions as of December 1989

Groundwater quality across the monitoring area (Figure 2) continues to remain at or near baseline quality. Well TW-18 shows higher concentrations of TOC (60 mg/L) and TDS (3,470) than the highest baseline values. However, there are indications that these increases result from movement of groundwater with naturally occurring high concentrations of TOC and TDS into the well monitoring area (#). Some benzene was detected at small concentrations (0.005-0.040 mg/L) in the cavity wells before and after the second pumping but was not detected in these same wells during the pumping. We believe that the benzene is associated with local deposits of coal tars in or around the well casings of the cavity wells which were used as process wells during gasification operations.

CONCLUSIONS

Careful selection of UCG sites based upon detailed site characterization can substantially reduce the potential for groundwater contamination resulting from UCG operations. If possible, a site should be selected with the proper hydrogeologic characteristics to help prevent flow of gases out of the UCG cavities and into the surrounding strata making potential for communication with near-by water bearing strata negligible. If conditions exist that do not tend to prevent the flow of gas from the UCG cavities into the surrounding strata, UCG operational constraints are critical for preventing the contamination of local groundwater.

The potential for groundwater contamination associated with UCG can be significantly reduced through the application of operational constraints and selected gasification termination and post-gasification operating procedures. Particularly critical is the control of cavity pressures during and after gasification. Pressures in the cavities need to be monitored and controlled at or below the hydrostatic pressure of the coal seam being gasified to minimize gas flow from the cavity into the surrounding strata and the importance of this constraint depends on the hydrogeologic characteristics of the site. The gasification cavities need to be continuously vented to cool the cavity, evacuate post operation products, promote collection and treatment of affected groundwater, and terminate coal pyrolysis.

These procedures were successfully demonstrated as a part of the RM1 UCG field test. To date, environmental monitoring results of the test show little impact to water bearing strata in the vicinity of the gasification test. This achievement is significant considering the test site did not possess ideal hydrogeologic characteristics for preventing groundwater contamination. Further, the pumping and treating of the UCG affected waters initially filling the UCG cavities after gasification were successful.

FINAL NOTE

The approach used in this program can be applied to other thermal recovery processes such as modified in situ oil shale retorting and oil

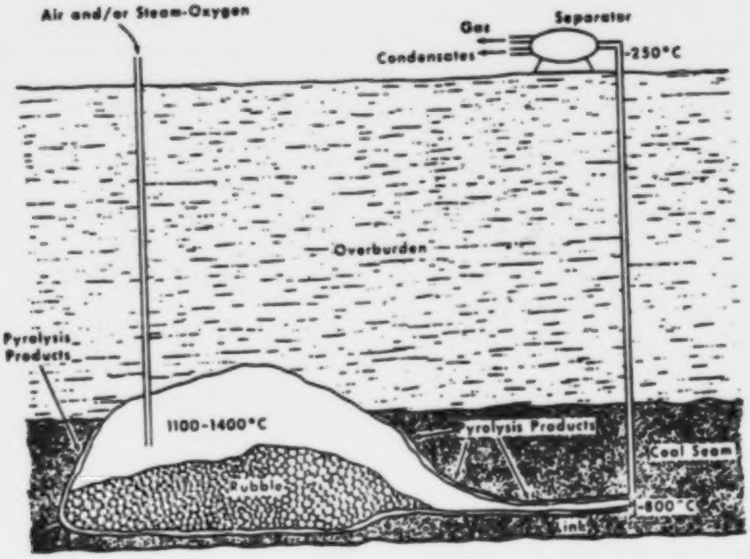

Figure 1. Underground Coal Gasification Reactor Schematic

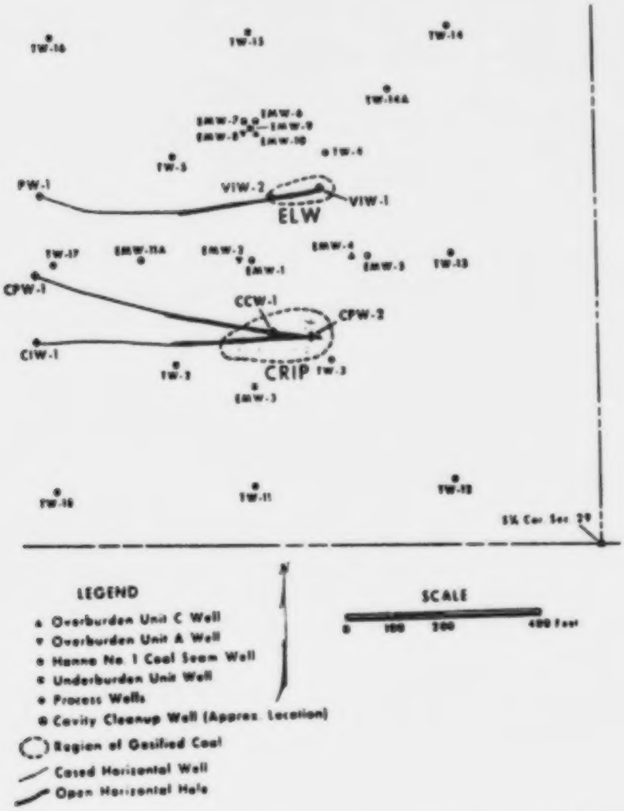

Figure 2. Rocky Mountain 1 Monitor and Process Well Layout

combustion drives. A similar program is being devised for Occidental Oil Shale Inc.'s planned modified in situ project (Boysen et al, 1990).

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BUSINESS TO BUSINESS NETWORKING - A CYCLE OR SHORT CIRCUIT?

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The Business Council of Alabama is a 501.C(6) non-profit member supported business association. It represents some 2200 member companies in Alabama. The membership is divided into more than 60 industrial classifications - from a single entrepreneur to a 20,000-employee textile plant.

The Business Council networks within itself and its membership concerning waste minimization, waste exchange and recycling programs through its Environmental Resources Committee. This volunteer committee is comprised of experts from the major manufacturing classifications in Alabama. Included are mining, chemicals, paper industries, contracting, hospitals, nursing homes and other companies who either produce or use products that add to the hazardous waste problem.

The Business Council, in turn, networks with the more than 80 other business associations in the state to supply expertise to their association members.

The Council sponsors workshops and shares information with the Automobile Dealers Association, Retailers Association, Service Station Operators, Textile Association, The Chemical Manufacturers Association, Cast Metals Association and other business organizations. Committee members appear on the agenda for regional, statewide and local seminars and before civic groups.

As Executive Vice President of the Business Council of Alabama, I operate as the coordinator for EPA Region IV waste minimization exchange for the COSMA group - The Conference of State Manufacturers Asssociation. This organization is the counterpart of the Business Council of Alabama. Within its membership are 43 states and Puerto Rico. The organization meets on an annual basis and the environment is one of the prime subjects on the agenda. COSMA is primarily political in nature and it concentrates on political solutions to the environmental problem and protecting business from punitive environmental legislation. The other part of our discussion centers on ideas for changing the image of business in relationship to the environment and discussing programs that enhance the environment in which business operates in each of the individual represented states.

No business wants to establish an operation in any state that does not have a strong environmental law and does not seek to protect its citizens from hazards of air, water and land pollution.

Not a single one of the 44 COSMA members operates in an ecological vacuum. To my knowledge, all are committed to structured economic growth in their state and at the same time provide a clean working and playing environment for its employees.

The business community has received negative publicity. It's the job of our associations, through networking, to make sure the story is clear and that the other segments of society accept their responsiblity for environmental degradation along with manufacturing. The business community recognizes that without healthy, productive workers, who are also consumers, that it cannot exist. No business prospers in the long run in an unhealthy environment.

The exchanges between the business communities through networking between the states is extremely important as new innovative ideas are developed. That information can be systematically replicated in other states. The exchange of ideas allows quick response to new ideas so that each state does not have to start from ground zero on each waste minimization idea or recycle idea. What may be a waste product in Alabama could very easily be a raw material for production in Mississippi.

I am currently working as the coordinator for the EPA Region IV states in developing a COMPACT within the eight southeastern states. At present four southeastern states are committed. Alabama has four states with which we have capacity assurance agreements - Tennessee, South Carolina, Kentucky and Alabama.

There are two states who are specifically banned from depositing hazardous wastes within the state. This ban is based upon legislation passed in Alabama in 1989. Within the COSMA group we are attempting to develop a COMPACT between the eight states to assure that we can accommodate hazardous wastes production within the region. The COMPACT, if reached will, of course, have to be approved by Congress.

In the meantime, as we work with the COMPACT concept we are in constant exchange of ideas dealing with recycling and waste minimization, and are currently exchanging ideas and information as to regulatory changes and state laws and regulations dealing with the disposal, creation and recycling of hazardous wastes.

The original question in the title of my text - "A Cycle or Short Circuit?" - at the current time, the hazardous waste exchange is working in full cycle, but as far as the COMPACT is concerned, it has now been short circuited.

We hope to clear up the short circuit and see the electrical circuit flowing again.

WASTE MINIMIZATION ASSESSMENTS AT SELECTED DOD FACILITIES

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ABSTRACT

The Waste Reduction Evaluations at Federal Sites (WREAFS) Program consists of a series of evaluations and demonstrations for pollution prevention and waste reduction conducted cooperatively by the Environmental Protection Agency (EPA) and other Federal agencies. The objectives of the WREAFS Program include: (1) performing waste minimization opportunity assessments, (2) demonstrating waste minimization techniques or technologies at Federal facilities, (3) conducting waste minimization workshops, and (4) enhancing waste minimization benefits within the Federal community.

This paper describes the WREAFS Program support of DOD activities in the pollution prevention area, and provides an overview of current projects being conducted at the Philadelphia Naval Shipyard, Fort Riley (Kansas) Army Forces Command, and the Naval Undersea Warfare Engineering Station in Keyport, Washington. Also described is a waste minimization research project with the Air Force. These DOD waste minimization opportunity assessments have identified waste minimization opportunities for a range of industrial and military operations including: metal cleaning, solvent degreasing, spray painting, vehicle and battery repair, ship bilge cleaning, and torpedo overhaul. The resultant waste minimization recommendations are source reduction methods including technology, process, and procedural changes and recycling methods, which focus on reuse or recycling.

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication.

INTRODUCTION

The purposes of the WREAFS Program are to identify new technologies and techniques for reducing wastes from industrial processes used by federal agencies and to enhance the adoption of pollution prevention/waste minimization (WM) through technology transfer. New techniques and technologies for reducing waste generation are identified through WM opportunity assessments and are evaluated through joint research, development, and demonstration (RD&D) projects. The information and data from these projects are then provided to both the public and private sectors through various technology transfer mechanisms, including project reports, project summaries, conference presentations, and workshops.

The waste minimization opportunity assessments are conducted by an assessment team that is composed of personnel from EPA, staff from the Federal facility that is cooperating in the program, and EPA's contractors. The assessments follow the procedures described in the EPA report Waste Minimization Opportunity Assessment Manual. This manual provides a systematic planned procedure for identifying ways to reduce or eliminate waste. The development of this procedure was supported by the Risk Reduction Engineering Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

As a result of joint waste minimization opportunity assessments (WMOA's), RD&D projects are identified with recommendations for pollution prevention. The demonstration projects are conducted under inter-agency agreements with joint funding by EPA and the cooperating Federal agency. Waste minimization workshops and other technology transfer methods are being used to communicate the results of these projects to the Federal community and the private sector.

WREAFS PROGRAM PROCEDURES

The WREAFS Program procedures used for conducting the waste minimization assessments are closely related to the WM procedures presented in the Manual. Figure 1 describes the course followed by a typical WREAFS project. The asseessments consist of four major phases:

(1) Planning and Organization - organization and goal setting;

(2) Assessment - careful review of a facility's operations and wastestreams and the identification and screening of potential options to minimize waste;

(3) Feasibility Analysis - evaluation of the technical and economic feasibility of the options selected and subsequent ranking of options;

(4) Implementation - procurement, installation, implementation, and evaluation.

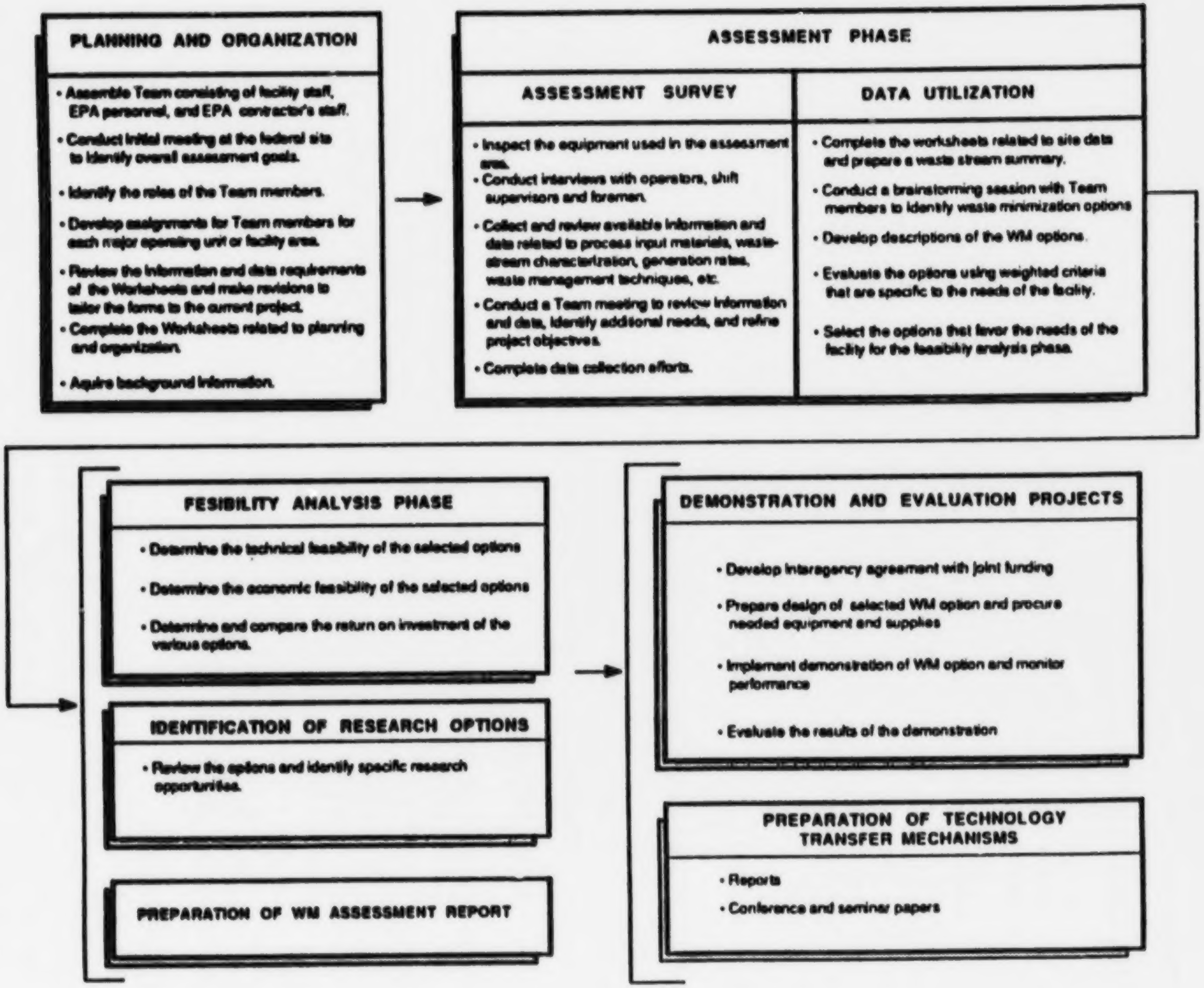
PLANNING AND ORGANIZATION
• Assemble Team consisting of facility staff, EPA personnel, and EPA contractor's staff.
• Conduct initial meeting at the federal site to identify overall assessment goals.
• Identify the roles of the Team members.
• Develop assignments for Team members for each major operating unit or facility area.
• Review the information and data requirements of the Worksheets and make revisions to tailor the forms to the current project.
• Complete the Worksheets related to planning and organization.
• Acquire background information.
ASSESSMENT PHASE
ASSESSMENT SURVEY
• Inspect the equipment used in the assessment area.
• Conduct interviews with operators, shift supervisors and foremen.
• Collect and review available information and data related to process input materials, waste-stream characterization, generation rates, waste management techniques, etc.
• Conduct a Team meeting to review information and data, identify additional needs, and refine project objectives.
• Complete data collection efforts.
DATA UTILIZATION
• Complete the worksheets related to site data and prepare a waste stream summary.
• Conduct a brainstorming session with Team members to identify waste minimization options
• Develop descriptions of the WM options.
• Evaluate the options using weighted criteria that are specific to the needs of the facility.
• Select the options that favor the needs of the facility for the feasibility analysis phase.
FESIBILITY ANALYSIS PHASE
• Determine the technical feasibility of the selected options
• Determine the economic feasibility of the selected options
• Determine and compare the return on investment of the various options.
IDENTIFICATION OF RESEARCH OPTIONS
• Review the options and identify specific research opportunities.
PREPARATION OF WM ASSESSMENT REPORT
DEMONSTRATION AND EVALUATION PROJECTS
• Develop interagency agreement with joint funding
• Prepare design of selected WM option and procure needed equipment and supplies
• Implement demonstration of WM option and monitor performance
• Evaluate the results of the demonstration
PREPARATION OF TECHNOLOGY TRANSFER MECHANISMS
• Reports
• Conference and seminar papers

Figure 1. An Overview of the WREAFS Program

Many of the WM opportunities identified during WREAFS projects involve low-cost changes to equipment and procedures that may be presently employed at other Federal facilities or within private industry. These WM opportunities can often be implemented by the facility without extensive engineering evaluations. Some other WM opportunities identified during these projects will require further study before full implementation can be realized. Typically, opportunities requiring further evaluation are those that have the potential for affecting the process and/or require the use of new procedures or equipment. In such cases it may be necessary to conduct demonstration projects.

Demonstration and Evaluation Projects

The types of research projects that can be pursued under the WREAFS Program are those that are expected to advance the knowledge and practice of waste minimization technologies and methods, and have broad applicability to Federal facilities and private industry. Depending on the nature and state of development of the WM option selected for demonstration and evaluation, these projects may include: (1) process design, (2) detailed design and specification, (3) system procurement, (4) installation and start-up, (5) monitoring, and (6) reporting. Some projects may require bench-scale and/or pilot testing prior to or as a part of the demonstration project. Other projects may utilize full-scale equipment directly on the production line.

CURRENT PROJECTS

Four WREAFS projects are being performed at DOD facilities. These projects are in various stages of completion. The assessment survey has been completed for several projects and the waste minimization options and research opportunities have been identified. Other projects are just underway. The following is a description of each project.

PHILADELPHIA NAVAL SHIPYARD

This project is being conducted in cooperation with the Environment, Safety and Health Office of the Philadelphia Naval Shipyard (PNSY). The shipyard has an ongoing program for waste minimization. With their guidance, several industrial operations were selected for application of the new waste minimization procedures. The shipyard plans to utilize the results from this project as a guidance tool for evaluating waste minimization opportunities at other industrial activities at the PNSY. The results of this project will be particularly applicable to facilities that operate aqueous cleaning and spray painting processes. However, the procedures employed to identify and evaluate minimization alternatives are applicable to most industrial operations.

Facility Description

The Philadelphia Naval Shipyard is the nation's oldest continuously operating naval shipyard. The shipyard now specializes in revitalizing and repairing ships already in fleet. The Service Life Extension Program (SLEP) is the shipyard's largest program. It is a comprehensive, keel-up restoration and modernization overhaul intended to extend the life of aircraft carriers by half, at about one third of the cost of a new carrier.

Selected Areas and the WM Options Evaluations

The procedure used for conducting the WM evaluation followed the EPA Waste Minimization Assessment Manual. The industrial activities selected for this project include areas used for the fabrication and surface coating of aluminum products, spray painting operations for steel parts, and a citric acid derusting operation, which is located at the drydocks.

The aluminum cleaning operation is performed to remove oil and other materials from the surfaces of aluminum sheets prior to welding. The cleaning line consists of four tanks: two process tanks, and two rinse tanks. The cleaning procedure consists of loading aluminum sheets into a metal basket, hoisting the basket into a process tank, and rinsing in one of the rinse tanks. The process water becomes diluted after repeated operation due to dragout losses and tap water replenishment. These tanks also collect floating oil, and the solution becomes contaminated with suspended solids. After approximately three months of operation, the process tanks are pumped to a tank truck and hauled by the contractor for disposal. The rinse tanks are operated as non-flowing rinses because of the low pH of the rinse water and the lack of facilities for neutralization. The rinse tanks are disposed of in the same manner as the process tanks but on a more frequent schedule, usually every two weeks.

Two WM options were evaluated for the aluminum cleaning operation. First, a dragout reduction and bath maintenance system was proposed. This system will include a hand-held spray rinse that will be applied over the process tanks. After affecting the parts, the rinse water will drip into the process tank. The spray rinse is expected to return 90 percent of the dragout back to the process tank. And 2, the acid baths accumulate oil and solids from the parts, and therefore, returning dragout losses may cause the process tanks to accumulate contaminants at a faster pace. These contaminants may interfere with the cleaning process; thus a bath maintenance system was recommended. This system would include an oil skimmer for floating oil removal and a cartridge filter for suspended solids removal. The dragout reduction and bath maintenance systems are expected to extend the usable life of the baths to one year.

A 2-stage rinse was proposed as an alternative to the existing rinse arrangement, where only one rinse tank is used after cleaning. The 2-stage rinse would make use of the existing tanks; however, some rearrangement was proposed to improve the layout of equipment and the efficiency of the operation. Using a 2-stage rinse would reduce the frequency of discarding the rinse water by allowing the first rinse to become more heavily contaminated. Then, after the first rinse is discarded and refilled with fresh water, the sequence of rinsing is changed (i.e., the cleanest rinse would always be the second rinse).

The spray painting processes are used for small and medium-sized aluminum parts, steel parts, and columns. Aluminum parts are degreased by wiping with rags that have been dipped into xylene. The parts are then spray painted in a water curtain booth. The painting process typically consists of a zinc chromate primer, air drying, a final enamel paint coating, and air drying. A new booth water chemical system was recently implemented. Spray painting of steel parts and columns is performed at various locations.

Several WM options were evaluated for the two spray painting operations. First, an operator training and awareness program option was evaluated that could reduce the amount of waste paint by controlling the amount of paint overspray, the amount of unused paint left in the can, and the amount of paint that is unusable due to partial solidification prior to use. Second, equipment changes were evaluated for the current compressed air paint spraying systems. Under consideration is the high-volume, low-pressure (HVLP) method. The transfer efficiency of HVLP is reportedly in the range of 65 to 90 percent. Compressed air equipment typically provides a 40 percent or lower transfer efficiency. Other WM options evaluated during the assessment included expanding use of a new paint booth chemical system and use of sludge dewatering equipment that would reduce the volume of paint sludge and recycle booth water.

PNSY employs a chemical cleaning process for ships' tanks, bilges, and void spaces termed the citric acid process. It is generally performed while ships are in drydock. This process is relatively new and it replaces the mechanical methods of cleaning and derusting metal surfaces. The process generates a spent citric acid/triethanolamine (TEA) solution. Owing to the significant material input costs and the high disposal costs, a recovery option was considered during the project.

Results at PNSY

The results of the assessment, which are presented in Table 1, indicated that the best options in terms of cost savings are the awareness and training program for paint waste reduction and the changes to the aluminum cleaning line including dragout reduction, bath maintenance, and improved rinsing. These three options offer a combined net savings in operating costs of $158,680 per year.

The citric acid/TEA recovery option was identified as a potential research project. A preliminary process design was prepared for the recovery process that included an electrodialytic membrane unit for separation and removal of dissolved metals. This type of technology has been applied to similar chemical solutions; however, its application to this waste has not been previously demonstrated.

FORT RILEY, KANSAS

Fort Riley is a permanent U.S. Army Forces Command (FORSCOM) installation that provides support and training facilities for the 1st Infantry Division (Mechanized), Non-Divisional Units, and tenant

TABLE 1. PHILADELPHIA NAVAL SHIPYARD SUMMARY OF WM FEASIBILITY ANALYSIS PHASE

Location Process & Waste	WM Options	Nature of WM Option	Total Cap. Investment $	Net Op. Cost Savings $/yr	Payback Period yr	Projected Waste Reduction lb/yr
Building 990						
Aluminum Cleaning Spent KRC-7X	Bath Maintenance	Equipment	$12,200	$44,190	0.3	$ 44,035
	Two Stage Rinse	Equipment	3,116	34,590	0.1	190,590
Spray Painting of Aluminum Paint Sludge	Booth Chemicals	Materials	12,190	5,430	2.3	-
	Paint Sludge Dewat.	Equipment	9,550	3,840	2.5	15,012
Used Paint Thinner	Awareness & Train.	Personnel/ proced.	24,266	79,900	0.3	unknown
Unused Paint	Awareness & Train.	Personnel/ proced.	See used paint thinner	-	-	-
Building 1028						
Spray Painting of Steel Paint Sludge	Booth Chemicals	Materials	3,300	5,460	0.6	27,022
	Paint Sludge Dewat.	Equipment	see bldg 990	-	-	-
Drydocks						
Citric Acid Derusting Conc. Citric Acid/TEA	ED Recovery System	Equipment	76,050	60,720	1.3	124,241

activities. It is a U.S. Government-owned, U.S. Government-operated facility. Fort Riley provides the U.S. Army with the capability to house and train an Army division and associated land combat forces as well as to service Army functions in an assigned Midwest support area.

Selected Areas and the WM Options Evaluated

The areas selected for assessment at Fort Riley were the Division motor pools located in various areas on the post. Routine mechanical maintenance is performed in these areas for trucks, tanks, armored personnel carriers, and other vehicles. Results of the Fort Riley, Kansas waste minimization assessment identified two waste reduction opportunities in a multipurpose building used for automotive subassembly rebuilding, lead acid battery repair, and other Army maintenance operations.

Battery acid (32-37 percent sulfuric acid) containing trace concentrations of lead and cadmium is currently drained from both dead batteries and batteries requiring repairs, e.g., replacement of battery terminals, and shipped in 15-gallon drums to a hazardous storage facility at the installation for ultimate disposal as a hazardous waste. It is proposed instead that the waste acid be gathered in a holding tank, filtered to remove any particulates, and adjusted in concentration to 37 percent sulfuric acid (using 60° Baume commercial sulfuric acid) as needed for reuse in reconditioned or new batteries. The buildup of dissolved metal impurities in this recycling system is prevented by purging part of the acid from the system. It is assumed in this assessment that 25 percent of the acid is purged and 75 percent is reused.

The dirty aqueous alkaline detergent solution for automotive parts cleaning, which contains trace concentrations of lead, chromium, and cadmium at a pH >12 as well as the oils, grease, and dirt removed from the automotive parts, is currently drained to an onsite nonhazardous waste evaporation pond. This waste, heretofore regarded as nonhazardous waste, is currently being reclassified as a RCRA hazardous waste due to its characteristics (D002, D006, D007, D008) and will have to be disposed of as a hazardous waste. The proposed waste minimization option for this waste stream involves emulsion breaking to remove the tramp oils, filtration to remove particulates, and addition of fresh alkaline detergent as necessary, followed by reuse for automotive parts cleaning. The buildup of impurities would be prevented by purging 25 percent of the used alkaline detergent and recycling 75 percent.

Results at Fort Riley

The waste reduction options identified in this study are recycle/reuse options. Presented in Table 2 are the results of the cost analysis phase. A net savings in operating costs is anticipated to be $149,400 per year. The expected payback periods for the two waste reduction options identified are very short. Successful application of these options at Fort Riley would create the potential for similar waste minimization options in at least 10 other U.S. Army FORSCOM installations.

TABLE 2. SUMMARY OF WASTE MINIMIZATION OPTIONS COST ANALYSIS DATA AT FORT RILEY, KANSAS

Operation Waste Stream	Waste Minimization Options	Total Capital Invest. $	Net Operating Cost Savings, $	Payback Period, yr	Projected Waste Reduction lb/yr
Battery Repair Shop/Waste Battery Acid	Recycle of waste battery acid	15,200	37,400	0.41	51,291
Automotive Subassembly Rebuild/Tornado Parts Washer Wastewater	Recycle of Tornado washer wastewater	19,800	112,000	0.18	181,395

NAVAL UNDERSEA WARFARE ENGINEERING STATION, KEYPORT, WASHINGTON

This project is being conducted in cooperation with the Naval Energy and Environmental Support Activity (NEESA) of Port Hueneme, California, in coordination with the Environmental Protection Division (Code 075) of the Naval Undersea Warfare Engineering Station (NUWES) Staff Civil Engineering Department. Several departments at NUWES Keyport are involved in an ongoing program to further the process of waste minimization on the Station. The draft version of this waste minimization assessment is currently under review by the Naval Undersea Warfare Station and detailed results of the study are not available.

NUWES Keyport is located within the central Puget Sound area of Northwestern Washington State. In 1978, the facility changed names from Naval Torpedo Station Keyport to NUWES Keyport recognizing that the functions of the Station had broadened to include various undersea warfare weapons and systems engineering and development activities. The principal activities currently conducted at NUWES Keyport are the design and testing of torpedoes.

Selected Areas and the WM Options Evaluated

Potential sources for waste materials include torpedo as well as other ordnance handling and related activities. Specific activities on the Station include welding, plating, machining, and sheet metal work; painting and stripping; electrical work; carpentry; fuel storage and use; power production; pest control; sanitary and industrial wastewater treatment; and associated storm sewer runoff. These activities generate a variety of potentially hazardous wastes, including fuel, oil, coolant, hydraulic fluid, and grease; various metals and plating bath liquids; paint and thinner; Freon, alcohol, mineral spirits, and other solvents; resin; acids and caustics; chromate and cyanide salts; wastewater treatment sludge; and detergent.

Two areas at the Station were examined in detail during the assessment. Both areas are used for the maintenance of torpedoes and have similar operations, processes, and waste streams. The major waste generating activities consist of defueling, disassembling, cleaning, reassembling, and refueling of torpedoes. The waste materials at these areas include: solids, liquids, sludges, solvents, and oils that are contaminated with Otto fuel, as well as diethylene glycol (DEG), mineral spirits (Agitene), and cyanide compounds. Waste minimization options were recommended for contaminated solids, contaminated liquids, and waste mineral spirits.

The waste minimization option for contaminated solids addresses all clothing that becomes soiled with Otto fuel (OF). Recommendations for the reduction of this waste are to segregate contaminated from non-contaminated clothing, and only dispose of the contaminated portion of a garment.

Automated parts cleaning is another waste minimization option recommended to reduce soiled clothing. In addition, the increased efficiency of an automated system will serve to reduce the amount of waste mineral spirits.

Contaminated liquids can be reduced in the Otto fuel tank draining area by installing another automated system that increases efficiency and decreases spills and contaminated solids.

At one site location, waste mineral spirits are currently pumped on a regular schedule from deep sink parts cleaners. This schedule is followed whether or not the solvents have become fouled. By monitoring the solvents and disposing only when fouled, the amount of waste cleaner will be reduced.

Preliminary Results at Keyport, Washington

The waste minimization options under consideration for NUWES Keyport are being evaluated for technical and economic feasibility. Projected waste reductions and costs are not available at this time.

U.S. AIR FORCE

In support of the Department of Defense's waste minimization program, the Air Force is seeking to obtain information for its chlorinated solvents recycling program. Air Force facilities are high-volume consumers of industrial solvents. Applications for solvents range from degreasing aircraft parts and missile guidance systems to cleaning small bearings and armament material. The major chlorinated degreasing solvent currently used by the Air Force is 1,1,1-trichloroethane. Due to toxicity and inherent health effects, the use of all chlorinated solvents may be curtailed unless effective waste reduction and recycling programs are developed. In this effort, an assessment will be performed for the recycling program at a selected Air Force base. The project is being performed in cooperation with Auburn University. Objectives for the study include developing mitigation technology for minimizing the accumulation of toxic contaminants in the recycled product and addressing concerns regarding solvent inhibitors and additives. The results of the study will be used to formulate a model program and establish protocols for operating solvent recycling technology service programs.

SUMMARY AND CONCLUSIONS

Waste minimization opportunity assessments conducted under EPA's WREAFS program are an excellent mechanism for promoting pollution prevention research at DOD facilities. At the three DOD sites audited, waste minimization opportunities have been identified for the following hazardous waste streams: aluminum cleaning solutions, paint sludge, paint thinner, unused paint, citric acid derusting solutions, waste battery acid, parts washer wastewaters, contaminated clothing, parts cleaning solutions, waste Otto fuel, and waste mineral spirits.

Pollution prevention recommendations have been made for the Philadelphia Naval Shipyard and Fort Riley that will reduce hazardous waste generation by a minimum of more than 630,000 pounds per year, with an annual savings of $383,530 at the two sites. In addition, a number of these opportunities will make excellent demonstration and evaluation projects.

The WREAFS program can be used as a catalyst to implement pollution prevention strategies and to identify research opportunities that would not be otherwise identified. Through this program EPA can assist DOD in transmitting new technical information to all of its facilities through project reports, workshops, seminars, and conferences.

CHROME RECOVERY VIA ADSORPTIVE FILTRATION

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ABSTRACT

Metal-bearing wastewaters are generated in large quantities at thousands of industrial sites in the U.S. The concentrations of metals in these waters may range from less than 1 to several hundred mg/L. The vast majority of these waste streams are treated by processes which generate a large amount of metal-containing sludge which then must be de-watered, transported, and buried in a controlled landfill.

The U.S. Environmental Protection Agency (USEPA), through the Office of Research and Development, has a national research program designed to support the intent of the 1984 Amendments to the Resource Conservation and Recovery Act of reducing the amount of hazardous and non-hazardous waste produced in the United States. This research program focuses on generation of data to allow the development of emerging new pollution prevention techniques.

The University of Washington, under a thirty-one month cooperative agreement with the USEPA, is evaluating the performance of packed beds of granular media coated with iron oxide and other adsorbents for recovering chromate from industrial waste solutions. The initial tests are being conducted using synthetic wastes. Following that, tests will be conducted using batches of real waste. A small recovery unit will be installed on-site at an industry near the University at the culmination of the project for pilot-scale evaluation.

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication.

INTRODUCTION

Recent work at the University of Washington has led to the development of a new material which may allow metals to be efficiently and cost-effectively recovered from metal-bearing wastewater. The material consists of either ordinary filter sand or activated carbon which has been coated with a thin layer of an adsorbent mineral such as iron oxide. When wastewater is adjusted to an appropriate pH and passed through a column packed with this material, the oxide coating adsorbs the soluble metals and filters out the particulate matter. Once the column's capacity has been exceeded, the material can be regenerated simply by passing another solution through at a different pH. The regenerant solution typically contains the metal at a concentration about 100 or more times that of the water which was treated. This process eliminates a major constituent which is generated during conventional treatment of metal-bearing wastewaters (iron or aluminum hydroxide) and generates a product stream from which the waste metals may be recycled or recovered, thereby avoiding both the cost and risks associated with disposal.

In October of 1989 the U.S. Environmental Protection Agency (EPA), Risk Reduction Engineering Laboratory began a thirty-one month cooperative agreement with the University of Washington to develop this technology as a recycling option for use at metal finishing facilities. Chrome containing wastewaters were selected as the target streams due to the toxicity and the volume generated.

The objective of this project is to evaluate the performance of packed beds of granular media coated with iron oxide and other adsorbents for recovering chromate from industrial waste solutions. The initial tests are being conducted using synthetic wastes. Following that, tests will be conducted using batches of real waste. A small recovery unit will be installed on-site at an industry near the University at the culmination of the project for pilot-scale evaluation.

The experimental tasks have been divided into three phases: (1) optimization of the process for coating the media with an adsorbent surface examining a) coating efficiency and b) dissolution of coating; (2) optimizing collection and recovery of chromate from relatively dilute synthetic waste solutions; and, (3) testing the process with real industrial wastes both at bench-scale and on-line at an industrial site.

DESCRIPTION OF THE TECHNOLOGY

Conventional technology for removing metals from solution involves precipitation of cationic metals as oxides, hydroxides, or sulfides, and then separating the particulate metals by settling, usually in conjunction with a coagulant such as iron hydroxide. This approach has several practical limitations, some of which are exacerbated when the metals are present in complex matrices such as many industrial wastewaters. Among these are that precipitation is ineffective for most anionic metals (e.g. CrO_4, SeO_3, VO_4) and for metals which are present as inorganic or organic complexes, and that those metals which do precipitate usually form small particles which do not settle readily. This means that large settling basins are typically required to collect the metals, usually followed by a sludge thickening operation. To ensure good treatment efficiency and good coagulation, massive amounts of iron salts are often added, significantly increasing the sludge generated in the process.

When ferrihydrite coated sand is placed in a column and a solution containing metals is passed through it, the coating can adsorb the dissolved metals rapidly and efficiently. At the same time, the column acts as a normal granular media sand filter to remove precipitated metals and other particulate matter. After some period of time, either the coating reaches its maximum capacity to remove metals or the filter requires backwashing. At this time, a pH-adjusted backwashing solution can be applied to recover the metals and regenerate the column for further use. Because the ferrihydrite is trapped on the sand particles, only the contaminant metals, not the ferrihydrite, are released. Since the sand and the associated ferrihydrite are retained in the column at all times a settling step is not required. This means the technology requires relatively small amounts of space and treatment chemicals.

The adsorptive filtration process generates a concentrated regenerant solution. This regenerant may be recyclable in the production process or have economic value to other users. In an industrial waste stream dominated by one metal, e.g. a segregated Cr(VI) waste stream in a plating shop, it may be possible to simply recycle the regenerant solution to the process.

INVESTIGATION OF THE COATING EFFICIENCY OF IRON ONTO SAND

Initial experiments were conducted to characterize the media prior to its exposure to any waste solutions. During work on optimizing the coating process, the amount of iron coated onto the sand, the efficiency of the coating process and the durability of the coating when the media is exposed to various physical and chemical stresses were evaluated. To determine the amount of iron which is typically coated onto the sand from various solutions, the sand was subjected to 10 coating cycles with each solution tested, and the concentration of Fe on the sand was analyzed after each cycle.

Briefly, a cycle consisted of pouring the solution over the sand and heating the mixture at 110°C overnight, at which time the sand appeared to be completely dry. At this point, the sand was weakly "cemented" together. The individual grains were separated by gentle grinding using a mortar and pestle. The grains were then rinsed for 15 minutes by placing them in a 200-mL graduated cylinder and flushing de-ionized water through the cylinder from the bottom at a rate sufficient to expand the media by approximately 25%. After 15 minutes, the flow rate was briefly increased to expand the bed to between 75 and 100% of its packed volume to rinse out any small particles which remained. The water flow was then stopped, a small sample of sand was taken, and new Fe-containing solution was added to start the next coating cycle. Sub-samples of coated sand from each cycle were placed in hot, concentrated nitric acid to dissolve the iron coating, and the resulting solutions were analyzed to determine the amount of attached iron.

The iron-containing solutions used in the coating experiments varied in terms of the associated anion (nitrate or chloride) and the amount of base added prior to the heating step. The concentration of iron in the coating solution was 1.45 M for the solutions made with iron chloride, and 1.30 M in those made with iron nitrate. Forty mL of iron-containing solution was applied to 150 grams of sand in each cycle, unless otherwise indicated. This amount of solution was just enough to cover the sand.

Figures 1 through 3 show the amounts of Fe attached to the sand after each coating cycle. Figure 1 shows the Fe attachment trend for two duplicate batches of sand coated using a solution of iron nitrate containing no added base, and for one sample using twice the volume of coating solution (80 mL of 1.30 M Fe per 150 g sand) per cycle as in the others. The results show good reproducibility with respect to coating efficiency. The amount of iron attached increases after most cycles. Although there are occasional cycles where the increment in attached Fe is zero or even negative, the overall trend is toward steadily increasing attached Fe concentrations, reaching 6.3% and 6.4% Fe by weight, respectively in the duplicate samples, and 11.1% in the sample using a double dose of coating solution. There was no indication that these values were approaching a plateau.

Figures 2 and 3 show the comparable data for coating solutions prepared with iron (III) chloride, rather than iron nitrate. In this case, when no base was added, some iron attached for a few cycles, but then was released from the surface in subsequent cycles. The amount of iron on the surface never exceeded 5% by weight of the sand, and at the end of 10 cycles the attached Fe was 3.0% and 3.7% by weight in duplicate samples.

Next, samples were prepared in which various amounts of based (10 M NaOH) were added to the coating solution prior to the heating step. The amount of base to add was chosen as follows. Base was added to the coating solution until a precipitate formed which did not dissolve when the solution was stirred and heated slightly. This occurred when the base addition was 0.38 mol NaOH per L of solution. The coating solution contained 1.45 mol Fe/L, so the base addition when the non-dissolving precipitate formed was equivalent to 0.206 mol OH/mol Fe. This was chosen as the maximum amount of base to add to any solution, and solutions were also prepared containing 25, 50, and 75% of this amount of base.

As Figures 2 and 3 indicate, the amount of Fe attaching to the sand was not increased significantly by the addition of 0.05 or 0.10 mol OH/mol Fe. As occurred when no base was added, the amount of Fe attached increased and decreased in an apparently random fashion, never exceeding a few weight percent. When the base addition was increased to 0.15 mol OH/mol Fe, the amount of Fe attached still fluctuated somewhat, but reached higher levels than in the samples with less base addition. However, when the full 0.21 mol OH/mol Fe was added, the amount of Fe coated increased quite steadily, reaching a value of 8.1% Fe by weight after 10 cycles. As with the coating cycles using an $Fe(NO_3)_3$ salt, there was no indication that the amount of Fe coated had reached a plateau.

ACID DISSOLUTION OF COATED IRON

The next set of experiments investigated the stability of the coating when exposed to acid solutions. In a full-scale operation, such exposure would occur either during acid regeneration of columns used to remove cationic contaminants (e.g. most metals) or during the treatment cycle of anions (e.g. chromate). In the former case, the pH of the acid solution would probably be around 2.0, with exposure periods of less than 1 up to about 2 hours per regeneration cycle. In the latter case, the exposure period would be much longer but the pH would probably not be as low. A pH value of 2.5 to 3.0 would probably be used in these cases.

For the acid exposure tests, a worst-case scenario was simulated, representing treatment to remove chromate at pH 2.0. The test protocol involved exposure of the media to a pH 2.0 solution for 20 hours, followed by 2 hours of exposure to a solution containing 1 M NaOH (approximately pH 14), followed by 2 hours without flow, in contact with the 1 M NaOH. During the periods with water flow, the flow rate was 10.9 mL per minute through a column packed with 21.8 mL of media, corresponding to an empty bed hydraulic detention time of 2 minutes. During each daily test, some fine particles appeared to settle atop the media. These were washed out by a very brief (<1 minute) backwashing step using the 1 M NaOH prior to returning to the pH 2 flow tests.

Two acid dissolution tests under these conditions have been completed. In these tests, the media used were those prepared with $FeCl_3$ and either the maximum base addition or 50% of this amount of base. Both sets of media had been coated in 10 coating cycles. The tests lasted 14 days, with samples collected every 2 hours. After 7 days and again at the end of the 14-day test, a sub-sample of the media was collected, and all the iron was dissolved off the grains. Analysis of the resulting solution provided a check on the estimates of Fe lost during the test up to that point. The results from these tests are presented in Figures 4 and 5.

The amount of iron released from the surface into the acidic water was typically between 0 and 1 mg Fe/L. The release pattern during a 24-hour period usually included a spike immediately after acid flushing began, followed by a gradual decline in Fe released for the remainder of the 22-hour exposure period. The amount of Fe released was consistently less in the sample which had been coated with the more neutralized (greater base addition) solution, particularly with respect to the spike at the beginning of each acid exposure period. Both because of the higher release rate and the lower initial coverage, the media prepared using the less-neutralized solution lost a significantly larger fraction of the total attached Fe than did the more highly-neutralized media (Figure 6). In this test using more highly-neutralized media, the daily Fe loss was limited to a few tenths of 1% of the attached Fe during the first 12 days of the test and decreased to only 0.1% during the last 2 days.

The amount of Fe detected in the acid dissolution effluents was considerably less than the total loss of iron from the media during the 2-week test period. The additional losses were apparently due to the backwashing of the fines during the brief backwashing step each day. These losses were significant during the first week, but appeared to be less or negligible during the latter parts of the test. For instance, although the total Fe loss during the 2-week period for the more- and less-neutralized samples was about 33% and 50%, respectively, in both cases over 90% of the 2-week Fe loss occurred during the first week. This suggests that even if a sample loses a good deal of its attached Fe in the early stages of its use, the remaining Fe is firmly attached and will not be easily lost. Similar tests with the media prepared using an iron nitrate solution are currently being conducted.

CHROMATE ADSORPTION TESTS

In the actual adsorption/recovery tests, waste solutions will be passed through columns packed with the coated media. A typical column will contain about 90 mL of bulk media. In order to characterize adsorption of Cr(VI) on to the coated media, Cr(VI) concentration, solution pH, and residence time in the columns will be measured. Three Cr(VI) concentrations will be tested: 10, 75, and 500 mg/L.

In the initial tests, the solutions will contain only deionized water and sodium chromate at the appropriate concentration. It is anticipated that tests will be conducted with each solution at 3 influent pH values. At each pH value tested, the test run will continue until the ratio of effluent to influent Cr(VI) concentration is at least 0.5. At this point the columns will be regenerated by exposure to a high-pH solution, as described below. At each pH value, at least one run will be conducted at each of 3 flow rates, yielding empty-bed hydraulic residence times of approximately 2, 5, and 15 minutes. If the capacity of the column for adsorbing Cr(VI) appears to be sensitive to flow rate in these tests, additional tests at other flow rates will be conducted. Based on the results of these tests with Cr(VI) only, operational parameters will be chosen for subsequent tests in which competing ionic adsorbates are present.

Tests will also be conducted using sulfate and Cr(III) as competing adsorbates. For these tests, only the pH and flow determined as optimal from the tests containing only Cr(VI) will be used initially. If the capacity of the media to collect CR(VI) from the solutions is significantly diminished in these tests compared to those with no competing ions, lower flow rates and different pH values will be tested in an attempt to improve performance.

The maximum chromate concentration attainable in the regenerant solution is important because it may ultimately control whether the regenerant solution has economic value (can be recycled). Based on results from previous tests, a single regeneration procedure will be chosen and used for the runs containing competing ions. If the regeneration efficiency in these runs is substantially worse than in those with no competing ions, the regeneration pH and/or flow rate will be changed in an effort to improve regeneration performance.

TESTS USING REAL INDUSTRIAL WASTEWATER

Chromate-containing wastewater from a local industry will be identified and treated using adsorptive filtration. The initial test runs will use operating parameters identified in the previous tests. Modifications will be made as appropriate to improve process performance, particularly if the process does not perform as efficiently as it did in the tests with synthetic wastes. Once the process has been operated successfully with the industrial wastewater at bench-scale, a pilot unit capable of treating approximately 1 gpm of the wastewater will be constructed and tested on-site. This unit will be subject to any changes in waste composition which occur in the real system, and therefore will provide valuable information about the stability of the system under transient loading conditions.

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Figure 1. Weight fraction of attached iron using a ferric nitrate solution.

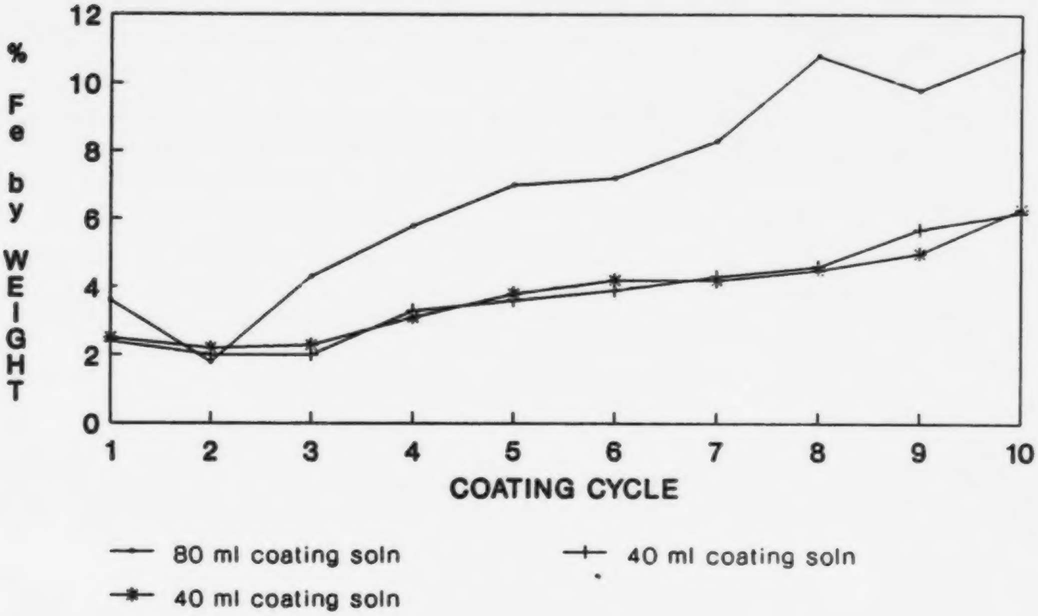


Figure 2. Weight fraction of attached iron using a ferric chloride solution.

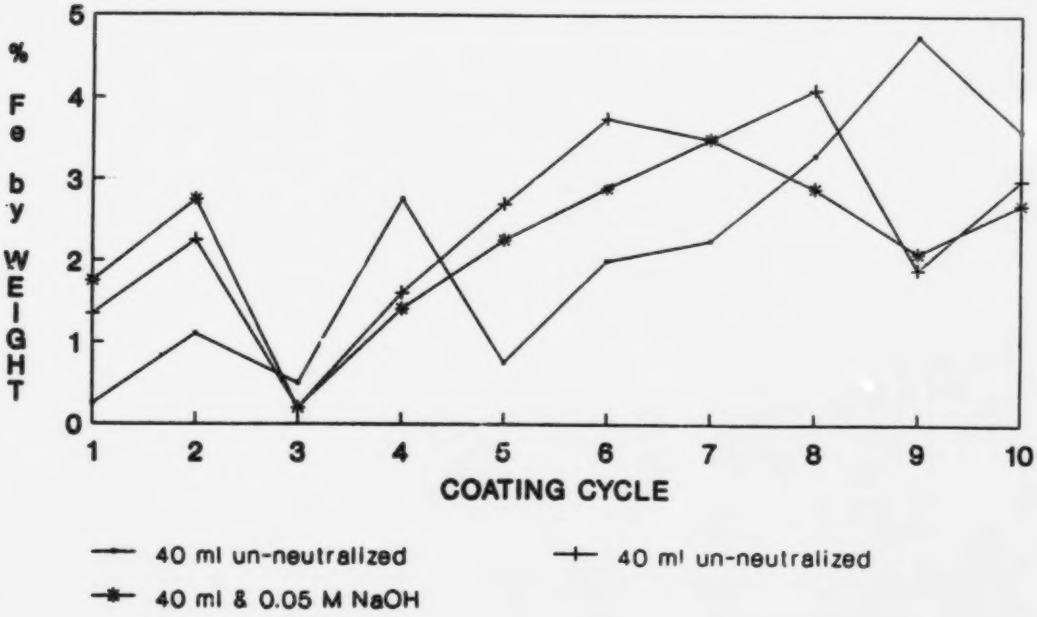


Figure 3. Weight fraction of attached iron using a ferric chloride solution

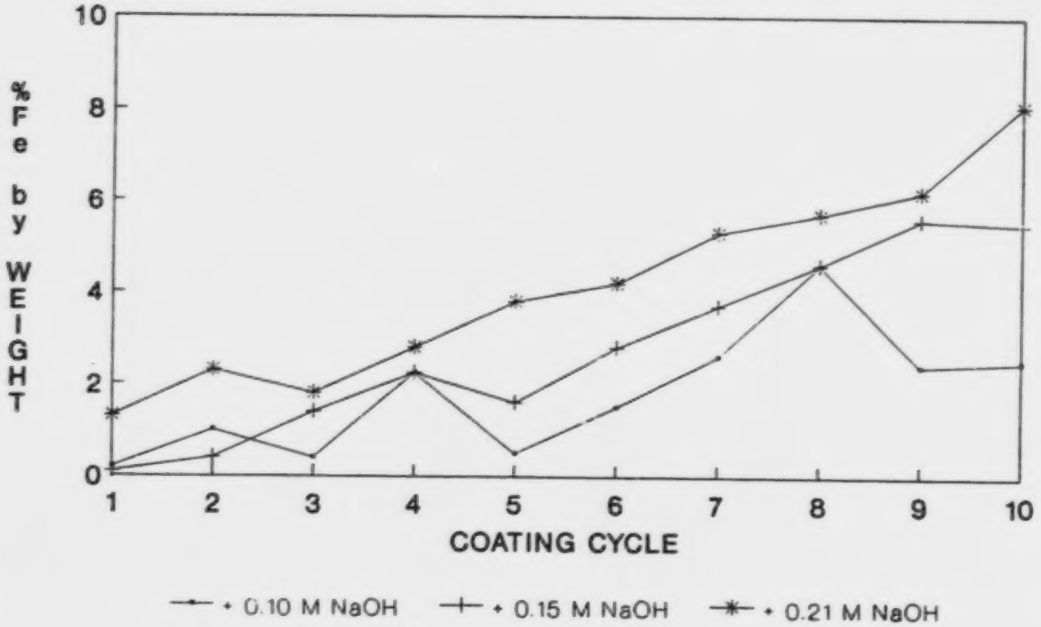


Figure 4. Iron Concentration in Effluent 1.45 M ferric chloride + 0.21 M NaOH

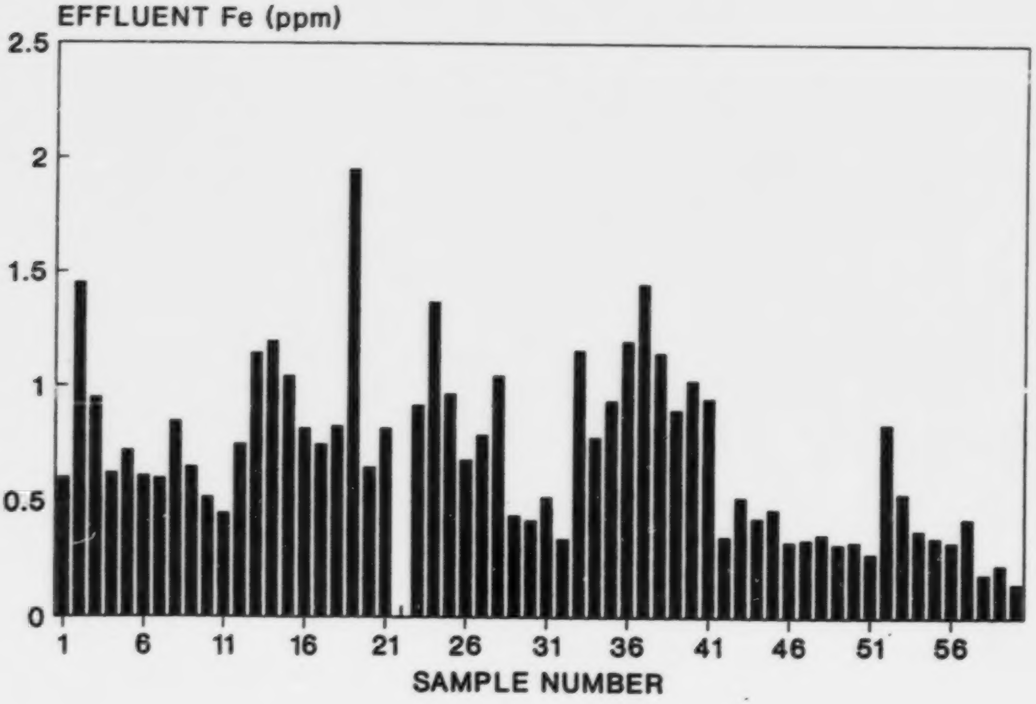


Figure 5. Iron Concentration in Effluent
1.30 M ferric chloride + 0.10 M NaOH

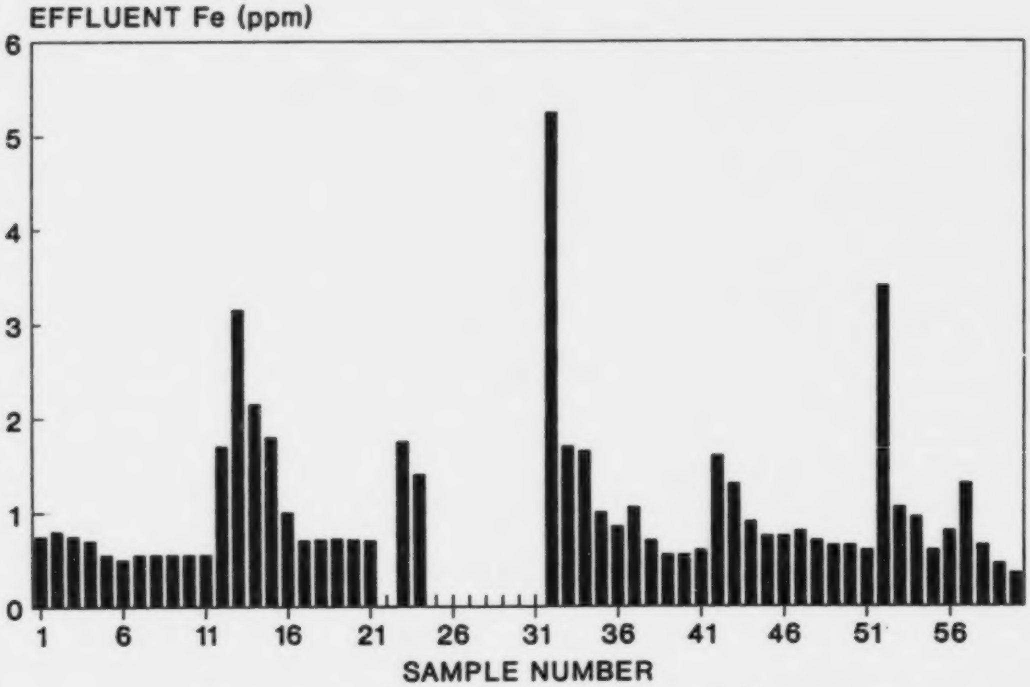
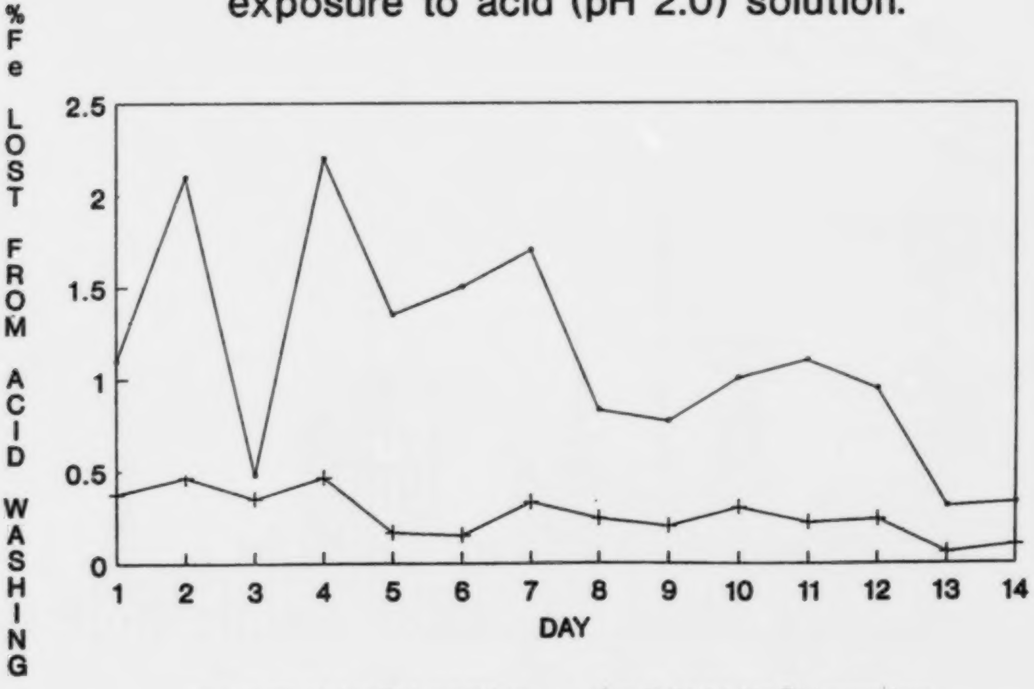


Figure 6. Loss of attached iron due to exposure to acid (pH 2.0) solution.



THE STATE OF OHIO POLLUTION PREVENTION TECHNOLOGY TRANSFER PROGRAM

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BACKGROUND

The Ohio Pollution Prevention Technology Transfer Program is the result of a collaboration of several agencies interested in providing assistance to business with hazardous waste problems. These agencies include the Ohio Environmental Protection Agency (EPA), The Department of Development's Ohio Technology Transfer Organization (OTTO), and W.S.O.S. Community Action Commission (WSOS). These agencies have taken a lead role in leveraging funds to be used to support a business assistance program. Program supporters have included the U.S. EPA (Washington, Chicago, and Cincinnati), The George Gund Foundation and the Cleveland Foundation.

The initiation of the Ohio Program began with a cooperative agreement between W.S.O.S. and OTTO in April of 1987. The purpose of the agreement was to form a working relationship to be better able to compete for federal funds in waste minimization. OTTO was working under the Governors mandate to provide such technical assistance along with the technical assistance that they normally provided to businesses. W.S.O.S. was just finishing a successful demonstration program of waste minimization in six northwest Ohio counties. The combining of these two agencies created a unique private/public partnership with access to: 32 outreach agents at colleges and universities; state and federal research laboratories; and waste minimization experts.

Thus far, this partnership has been very lucrative. In 1988 WSOS/OTTO wrote an application on behalf of the Ohio EPA. The application was in response to a solicitation from the U.S. EPA announcing the availability of ten grants to conduct RCRA Integrated Training and Technical Assistance (RITTA). The Ohio proposal outlined a coopertive approach among Ohio EPA, WSOS, and OTTO staff in designing and delivering an innovative one-on-one technical assistance program for businesses. Ohio's proposal was ranked second in the nation.

AGENCIES INVOLVED

WSOS is a community action agency operating in the four northwestern Ohio counties of Wood, Sandusky, Ottawa, and Seneca. In addition to the various human service activities conducted by WSOS, they also are Central Office and administrating agency for the Great Lakes Rural Community Assistance Program (GLRCAP). The GLRCAP program is a seven-state training and technical assistance center operating in Illinois, Indiana, Kentucky, Michigan, Ohio, Wisconsin, and West Virginia. GLRACP was formed in 1980 to assist rural communities attain and maintain sanitary water and wastewater systems. Our efforts in this field has lead us into other areas of water management with GLRCAP serving as the environmental component of WSOS. This has proven to be an ideal position from where we have been able to affect positive changes in the environmental condition of rural areas.

OTTO is Ohio's official waste minimization information system, charged by Governor Richard F. Celeste with providing training and technical assistance to Ohio's industrial and business communities. As a non-regulatory body, OTTO can deliver technology, materials, and information about waste issues to any Ohio company. OTTO has a network of 32 trained agents housed at 23 two-year colleges and five major universities throughout the state. Each agent offers timely, direct, and local access to definitive resources, including commercial databases, federal laboratories, and the faculties to member institutions. OTTO also provides those agents with the expertise of an engineering specialist and two business management specialists, as well as the Waste Information Network (WIN) library of resources at its Ohio State University Research/Resource Center. Since 1979, OTTO has promoted Ohio's economic development by brokering technical information and expertise from the higher education system, federal laboratories, and other sources of Ohio's business and industry. OTTO's objective in waste management, as in all other activities, is to help Ohio companies become more productive and competitive through the application of modern methods and techniques.

OHIO'S BUSINESS ENVIRONMENTAL TECHNOLOGY TRANSFER PROGRAM

Currently the Ohio program is completing the RCRA Integrated Training and Technical Assistance grant, which has three major objectives: the development of a State Training Action Plan, the implementation of training for state environmental personnel, and the conductance of technical assistance. Ohio's plan differs from most other States by incorporating an innovative technical assistance approach. This approach is the basis for the Ohio Business Environmental Technology Transfer program as well as most of the report. The other elements of the program and additional activities mobilized as a result of the receipt of U.S. EPA funds, however, will provide many opportunities for Ohio businesses.

STATE TRAINING ACTION PLAN (STAP):

The STAP is basically an outline detailing long-term plans to achieve RCRA program goals using training and technical assistance techniques. The STAP will set forth plans for both training directed toward environmental industrial/regulated community, outline a focused pilot project in waste minimization as well as establish plans for developing and implementing an Integrated Compliance Strategy (ICS). The Ohio EPA has organized a Waste Minimization Task Force (WMTF), which reports directly to the Director of the Ohio EPA. The WMTF has been charged with the responsibility of assessing the Ohio's needs relative to hazardous waste minimization. The WMTF has been of individuals representing the following ten agencies or groups:

- Ohio General Assembly
- Ohio Manufacturers Association
- Attorneys
- Ohio Environmental Council
- Ohio Public Interest Council
- Battelle Institute
- Ohio Chamber of Commerce
- Ohio Technology Transfer Organization
- Environmental Activities
- Engineering Department, Ohio State University

The WMTF will serve as the team that will work with OTTO staff to design and develop the STAP. Such a team effort will ensure that the Ohio STAP is responsive to the needs of the EPA and the regulated community.

The Lead agency for the development of the STAP is OTTO. A full-time environmental specialist will be assigned to work with the Waste Minimization Task Force (WMTF) to oversee, and develop the STAP, in conjunction with assistance from the Ohio EPA, the National Environmental Training Association (NETA) and the Center for Hazardous Materials Research. The OTTO staff person will be responsible for assessing Ohio EPA needs and working closely with external agencies.

All existing state training programs will be evaluated to assess the total system performance. The evaluation will help determine successful elements that could be incorporated into the STAP, as well as to identify gaps in the present state training programs that need to be supplemented in the STAP. Based upon input from the Ohio EPA, WMTF, WSOS, and the business/industrial community, a five year projection of training and technical assistance goals will be established. Some of the factors that will be taken into consideration will include data on Ohio's waste generation community, and trends in the political arena that will effect both the regulator and the regulated. Realizing that it is impossible to predict the type of training and technical asistance that will be needed in the future we can only assume from previous experience that there will be an overall decrease in the need for initial training relative to procedure and waste minimization technical assistance; and an increase in advanced training, relative to specific issues as well as for orientation training of new staff.

Perhaps the most significant section within the STAP will be the outline relative to future funding of the Ohio program. The plan will identify and evaluate potential sources such as: state support; disposal fees/tax support; fee for service programs; subscription newsletters; self sufficient or profit making conferences; workshops and trade fairs; and private sector involvement. Ohio is already investing funds by annually supporting OTTO at $1,600,000. In addition, in-kind support from technical schools and universities, contribute to the Ohio Pollution Prevention Program.

Strong public and corporate/industrial awareness and support is essential to develop a State Training Action Plan and State program that will effectively minimize hazardous wastes in the State. Because the industrial/corporate community will be involved in the development of the STAP, as well as the waste minimization project, Ohio's program will be at a distinct advantage from the beginning in building awareness and support among the industrial sector. To gain additional support from this group, we plan to increase their awareness of our program.

TRAINING FOR STATE ENVIRONMENTAL PERSONNEL

The State Environmental Personnel will be some of the same individuals and agencies that will be responsible for designing the STAP and for conducting the demonstration program. Specifically this will involve staff at the Ohio EPA, OTTO, and WSOS. The training of these State Environmental Personnel will involve three specific aspects: interagency, outreach, and one-on-one. Each type of training will target a specific technical assistance provider and will be integrated into the complete Ohio waste minimization program.

INTERAGENCY TRAINING: Interagency training will involve working out an efficient working relationship among all agencies involved in training and technical assistance. All three agencies involved are independent agencies that are working on waste management and minimization issues. Each brings to the team unique expertise and capability. This training element will be the initial training required to implement the program. Continued training activities will be identified and will evolve over the course of the program. Some of the training activities/issues will include:

- Ohio EPA internal staff training,
- State environmental personnel cooperative training,
- RCRA compliance training,
- Waste minimization techniques, and
- Resource utilization and availability.

OUTREACH TRAINING: The outreach element of our program will serve as the initial contact between the business community and our program. The objective of the outreach element is to determine the assistance required by the owner/operator for the business to implement a waste minimization program. The training will involve increasing the awareness and capability of outreach staff. This may involve developing manuals and/or survey forms that will allow the outreach staff to effectively assess the businesses needs.

ONE-ON-ONE TRAINING: The one-on-one element of our program represents an innovative method to insure that businesses receive the information that they need to specifically implement waste minimization. Many technical assistance programs fall short of being able to quantifiably reduce wastes because they do not follow through and address the specific needs of the business. This training element will involve increasing specific technical knowledge and establishing a working relationship between the one-on-one technical assistance providers and the Ohio EPA and the USEPA. Training will also involve a cross training element between the outreach and one-on-one staff to increase the flow of information and the exchange of ideas between these two components.

Initially, only general orientation training will be conducted. This training will bring all Ohio EPA staff and state environmental personnel up to date relative to regulations and new legislation. The orientation training will also outline goals and objectives of the Ohio Program. The orientation training will also serve as an initial coordination program between Ohio EPA staff and OTTO/WSOS outreach and technical assistance staff.

In addition to the orientation training, the following type of training will be conducted: (1) Training State technical assistance specialists and inspectors to provide assistance to generators in identifying and implementing waste minimization project opportunities and activities; (2) Training a technical assistance team to provide waste minimizaiton support and to identify management coordination needs; (3) A joint training session for RCRA, Water Quality, and Air Quality waste minimization assessments; (4) On-site facility training; and (5) Training of the media and general public.

TECHNICAL ASSISTANCE PILOT PROJECT

The primary emphasis of the Ohio Program utilizes the successful model designed and implemented by WSOS and the existing outreach capabilities of OTTO. The model is a one-on-one training and technical assistance program, conducted by a nonenforcement entity, using the technical experience and cooperation of the Ohio EPA as a support agency. With this model, we are able to gain the trust of businesses and, therefore, provide them with the specific assistance that they require to achieve waste compliance and minimization.

With a pilot program initiated by WSOS, we have already been able to: increase the number of businesses complying to the RCRA regulations, increase awareness for the necessity of compliance to RCRA, and assist several businesses to quantifiably minimize the amount of hazardous wste generated. More importantly, we have been able to gain the confidence of the business community, thereby, increasing their willingness to contemplate waste minization. In the process, we have demonstrated that proper management and minimization of wastes is not so much a business expense as it is a long term economic savings.

The goal of the Ohio program is to establish a training and technical assistance program within the State that will successfully assist business on environmental issues. To achieve this goal, an innovative state-wide outreach model was established. The model involves the linkage of various agencies to conduct training, technical assistance, information exchange, and one-on-one assistance. In addition to the agencies that have primary responsibility for business technical assistance, the model incorporates other agencies such as: Private Industry Councils (PIC), Community Action Agencies (CAA), the Ohio Chamber of Commerce and local chambers, and Ohio colleges, Universities, and technical schools. The actual services delivered or planned for delivery are elaborated on below.

TRAINING: The first element of our program involves detailed training of the individuals and agencies that will be involved in the waste minimization program in Ohio. Most of the elements of this training have been detailed earlier. We propse an innovative training component to increase awareness for waste minimization by segments of the Ohio business community other than and in addition to the generators.

ONE-ON-ONE: Our one-on-one approach is the cornerstone of the program. Because of the success that has been demonstrated with this approach, we are confident that other methods used to achieve reduction of wastes will directly and indirectly benefit. All direct technical assistance involves an OTTO/WSOS staff member working with the business in a one-on-one capacity. In this manner we can provide the information and assistance required to minimize waste at that facility. We believe that a successful one-on-one program will allow us to effectively conduct need surveys, sponsor well attended workshops, etc.

OUTREACH: Our primary outreach will be via the thirty-two OTTO agents located in community colleges throughout Ohio. As these agents assist businesses they will also assess hazardous waste management and minimization practices, and provide assistance and referrals as required.

SURVEYS: A survey form will be designed that can be used to assess business needs relative to waste minimization and other environmentally related issues. The survey form will also be made available to other agencies that routinely work with businesses such as: economic development centers, chamber of commerce, community action agencies, small business centers, etc.

MANUALS: We have already produced a guidebook for small businesses. Based on the needs identified, we plan to produce additional manuals targeted towards waste minimization in various industries.

ARTICLES: Perhaps one of the best ways to reach owners/operators is to publish information in trade magazines. As case histories become available, articles will be written relative to effective examples of waste minimization and pollution prevention.

NEWSLETTERS: The newsletter prepared by OTTO now contains information on environmental issues. This is provided gratis to Ohio business. The newsletter describes, in layman terms, the new environmental regulations as they pertain to Ohio businesses and provides a forum for brief case histories. Other features that may be added include: a question and answer section, a material trade/exchange section, an analysis of waste minimization products, etc.

LECTURES: We will accept invitations to talk about waste minimization at local conferences. We also plan to approach trade and vocational schools to talk to students who plan to open their own businesses about waste minimization.

SUMMATION:

The first year of the project can only be rated as a huge success even though we have in no way achieved all that we still want to accomplish. The merger of OTTO and WSOS hazardous waste programs was done "on-the-run" as we implemented the program. Often this caused delays when we wanted to proceed at a more rapid rate. The results, however, speak for themselves. A total of 437 hazardous waste generators, representing an average of 1.2 per calendar day, received direct one-on-one technical assistance with specific waste minimization problems. Newspaper articles describing the merit of the program and the merit of waste reduction appeared in 35 papers. Over 370 generators and over 400 representatives of other associations attended the various workshops and conferences sponsored or co-sponsored by OTTO and/or WSOS. Over 3400 items of information were distributed in the form of flyers and newsletters to an average of 850 generators per quarter.

For year two of the program, our plan is to continue at the same or higher level of service delivery. In addition, we will begin to quantify in terms of volume and impact the amount of hazardous waste diverted from the environment.

THE USE OF ECONOMIC INCENTIVES FOR THE INTRODUCTION AND ADAPTATION OF CLEAN TECHNOLOGIES

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INTRODUCTION*

The adjustment pressures on the economies of developing countries to pursue their industrialization have increased drastically and so has the damage caused to the environment and natural resource base on which economic growth depends. It is evident that damage is being caused to the natural environment by the technologies and practices employed in industrial development and less harmful alternatives must be discovered and applied. For both developed and developing countries, the challenge to face is to continue their economic and social development in a sustainable way. That is, to ensure that they meet the needs of the present without compromising the ability of future generations to meet their own needs.

Technological innovations have the potential of achieving this objective. How to use technology is not always a simple decision, but above all is an important one, upon which our survival depends. Technology constitutes one of the most important factors of the industrialization process, which is a necessary condition for economic development.

A significant outcome of technological progress is the development of clean methods of production which not only have major economic and technical, but ecological implications as well. Clean technologies reduce production cost through savings in raw materials and energy and increase productivity, which in turn leads to increased profitability and competitiveness. On the other hand, clean technologies limit discharge, avoid the production of by-products and reduce the risks of accidental pollution and transfer of pollution between physical environments.

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Nevertheless, new and clean technologies are mostly developed by industrial countries, and in one way or another, developing nations are highly affected by technological developments abroad since for the majority of these countries new technologies have to be acquired from abroad rather than developed domestically. Moreover, the technological feasibility, the complexity of economic and environmental problems and the financial implications of solutions are different in industrial nations and developing countries. Namely, it is economically more difficult for developing countries to promote economic development and protect the environment at the same time.

However, measures to assist developing countries to review both economic development and environmental quality are now needed more urgently than ever. In addition, developing countries should be assisted in establishing the conditions for developing clean technologies themselves or in building their capabilities for technology acquisition.

The main objective of the present study is to promote economic mechanisms that could induce developing countries in transferring and applying clean technologies. In pursuing this objective, we consider and analyze the implications of two policies. The Polluter Pays Principle which focuses on the identification of pollution generating sources and penalizing the polluter, and the use of subsidies in order to assist enterprises or industries to transfer, introduce, and adapt clean technologies.

The paper is divided into three sections. Section 1.0, defines the Polluter Pays Principle and analyzes the implications of its implementation through direct controls and taxes. Section 2.0, examines the effectiveness of subsidies as an alternative policy measure and describes the various types of subsidies. Finally, a summary of the main conclusions of the paper are discussed along with their implications for future policy decisions.

1.0 THE POLLUTER PAYS PRINCIPLE AND ITS IMPLEMENTATION

1.1 Environmental Resources and Market Prices

In a market system, consumers express their preferences for commodities by their willingness to pay the price attached to them. But payment of the price is not always a necessary condition for obtaining commodities (Mayer, 1975). Namely, some commodities that serve economic functions, are not represented in the price mechanism and can be obtained without paying a price, such as public goods and environmental resources. When an environmental effect is not automatically taken into account by the price mechanism, it is considered an external effect. In other words, the environmental impact of economic activities by one or more economic unit(s) on the welfare of others are treated as externalities.

Environmental externalities result from both production and consumption activities and develop rapidly as an economy grows with a substantial impact on the society at large. They are generally considered as the major reason for the discrepancy between private and social cost and result in misallocation of economic resources (Pearce, Markadya and Barbier, 1989).

Environmental externalities and the resulting misallocation of resources can be corrected, partially or wholly, through the price mechanism if a price is placed on environmental resources so as to narrow the gap between private and social cost. That is, free market prices must be determined in such a way as to reflect the true cost of production including the value of environmental damaged caused by any economic activity. The correct prices then should be:

$$P = MC + MEC = MSC \qquad (1)$$

Where, MEC is the marginal environmental or marginal external cost expressed in money terms. For a non-polluting product there is no difference between private and social costs of production and therefore the marginal external cost is zero and the proper price becomes:

$$P = MC = MSC \qquad (2)$$

On the other hand, the proper price for a polluting product or service should reflect the environmental damage as it has been expressed in formula (1). Thus, there is a need to correct the market prices of polluting products by making the polluter pay the differential amount. This is the process of internalization of externalities which we discuss in the following section.

1.2 Definition of the Polluter Pays Principle

The central theme of any environmental policy is the internalization of externalities that can be resolved through effective policy instruments aimed at allocating the most relevant costs and benefits to society. To this end, a common environmental policy on pollution prevention has been accepted and implemented by many nations and in particular among the members of the Organization for Economic Cooperation and Development (OECD).

The objective of this policy is to allocate the pollution control cost to polluters, and it is called the Polluter Pays Principle (PPP). The Polluter Pays Principle implies that it is the responsibility of the polluter to meet the costs of pollution control and prevention measures, irrespective of whether these costs are incurred as the result of the imposition of some charge on pollution or in response to some direct regulation. It is also irrelevant whether the polluter passes on some or all of the costs to consumers in the form of higher prices or absorbs them (OECD, 1975).

There are various mechanisms making the polluter pay for the pollution control costs. In this paper I consider and analyze the implications of two such mechanisms, i.e., direct controls and taxes or changes. According to Baumol and Oates (1975), the difference between direct controls and taxes or fees is that direct controls are enforced through fines or other penalties and involve a directive to individual producers requiring them to satisfy some predetermined environmental quality standards. If their activity satisfies these requirements, they are legal and no penalty is imposed, but if the standards are violated they are subject to punishment. With taxes or fees on the other hand, even if they are based on standards, the producer is not told what level of economic activity to select. The amount of payment will vary with his activity level, with no imputation of illegality to the activity level he chooses.

1.3 Direct Controls

One mechanism through which the polluter pays principle can be implemented is direct controls aimed at forcing the polluter to pay the cost of cleaning the environment of his generated pollution or to order him to utilize a clean technology for producing his output. In order to comply with predetermined standards set up by public authorities, the polluter must pay a lump-sum equal to the clean-up cost or pay the cost of pollution prevention equipment.

The impact of the above policy is an increase in the total cost of production borne by the polluting firm. But as with any increased cost, the producer may be able to pass some or all of the pollution control cost on to consumers (through higher prices) depending on the elasticity of the demand and supply curves. Namely, the more elastic the demand curve is (the higher is the competition) the more the increased costs will be borne by the producer and less will be passed on to consumers. In reality, the environmental control cost is shared between the firm through reduced profits and the consumers through higher commodity prices (Pearce, Markadya and Barbier, 1989).

Direct controls are the safest means of preventing irreversible effects or unacceptable pollution levels and their effectiveness depends mainly on good administrative organization, on which efficient environmental management also depends (OECD, 1975). It should also be noted that direct controls are mainly preferred by industrialists, because controls are open to bargaining and compromising over the fixing of the standards and once the polluter has complied with the regulations, he has no further charges to pay. In addition, direct controls are flexible since they can induce changes in polluting activities and this is another reason for their popularity among regulators (Baumol and Oates, 1975). Moreover, direct controls are consistent with the PPP if each polluter affected by the controls has to bear the cost necessary for complying with the standards (OECD, 1976).

1.4 Pollution Charges or Taxes

Another mechanism through which the polluter pays principle can be implemented is by imposing a per unit tax or charge on the product itself, resulting in raising the cost of producing the product. The effect of a tax is that it adjusts market prices to reflect the use of environmental resources, which otherwise would be treated as being free. The amount of the tax must be equal to the marginal external cost so that private and social costs become equal (Formula 2). More specifically, the tax must be equal to the amount at which the marginal social costs of pollution abatement equal to the marginal social damage from pollution. If this tax is imposed, the polluter will reduce the polluting input up to the point where a further reduction in this input (further reduction in pollution) will cost him more per unit than paying the tax, because he would prefer to pay the tax beyond this point (OECD, 1976).

The amount of the tax should also have some relationship to the value of environmental resources used in the production of a given product. For example, soft coal with high sulfur content should be charged a higher tax than hard coal with low sulfur content. A higher tax on leaded than unleaded gasoline may induce consumers to use unleaded gasoline so that to improve air quality standards.

Pollution charges or taxes, on the other hand, play an important role in the process of internalizing environmental externalities. First, unit taxes represent a very attractive method for achieving specific standards of environmental quality, and they automatically lead to the least-cost pattern of modification of externality-generating activities (Baumol and Oates, 1975). Second, pollution charges or taxes oblige the polluter to include in his production cost the pollution control cost and by doing so he re-establishes correct pricing, so that the gap is bridged between private and social cost (OECD, 1975). Third, a charging policy may achieve the objective of abating pollution at least cost to society and it can provide a continuing incentive for improved pollution abatement (OECD, 1976). Finally, the application of charges in promoting clean technologies make the cost of pollution visible to manufacturers, and the revenues from the charges can be used for environmental investments (Economic Commission for Europe, 1989).

The two policies we have discussed so far have different effects on product prices. With direct controls, the first is forced to pay a lump-sum environmental control cost which does not alter the initial prices created by the market. This implies that the polluter will pay the same cost regardless of what amount of the polluting input is employed in the production process, unless environmental quality standards change. On the other hand, imposing taxes on polluting inputs or products raises the prices of these products and makes them less attractive to consumers. Market prices determined that way reflect both the use of economic resources as well as of environmental goods and achieve a more efficient allocation of scarce resources.

Pollution charges or taxes, however, are generally considered more effective and should be used to internalize abating pollution costs. The basic reason why pollution charges are likely to be better than forcing the pollutant to bear the pollution cost is that: "charges enable a polluter to choose how to adjust to the environmental quality standard. Polluters with high costs of abating pollution will prefer to pay the charge. Polluters with low cost of abatement will prefer to install abatement equipment. By making abatement something that low cost polluters do rather than high cost ones, charges tend to cut down the total cost of compliance" (Pearce, Markadya and Barbier, 1989).

2.0 FISCAL INCENTIVES

2.1 Subsidies

As national environmental policies are applied, it seems that strict enforcement of the Polluter Pays Principle may create economic difficulties for certain enterprises, industrial sectors, regions or countries. In such cases making the polluter pay is not practical, and a transitional policy can be adopted to facilitate adjustment. This being so, exceptions can be made to the PPP when there are special circumstances which the authorities regard as justifying them. Such situations could arise when application of the PPP would hinder the achievement of one or more regional or national economic objectives.

This would be the case, for example, when the additional environmental control cost incurred by polluting industries in developing countries would result in holding back regional development or adversely affecting the labor market. In addition, to abate pollution, changes in production technology are required in many cases, which may cause distortions in the operations of an enterprise or industry. Production lines may have to shut down, economies or scale may have to be sacrificed temporarily, and workers may have to be laid off. Another situation may arise when an enterprise or industry in a developing country, in order to abate pollution, must apply a new cleaner technology which has not yet been introduced in the country in question. Then this technology must be transferred from abroad which in many cases is very costly.

Under these circumstances, a case can be made for public assistance to help a firm or an industry to meet transitional adaptation costs, so that the public as a whole will benefit from the process of maintaining a viable balance between environmental and other economic or social goals. Although the sharing of transitional adjustment costs, through public or international assistance constitutes a departure from the spirit of the PPP, it seems that the general problems of adjustment and policy implementation require exceptions to be made in the aforementioned special cases. Furthermore, exceptions to the PPP have been widely accepted in the form of "adjustment assistance" under a wide variety of circumstance, ranging from import competition to the effects of rapid technological change (Walter, 1978).

The major goal of implementing efficient environmental policy then should be to minimize adjustment costs, and nationally or internationally financed programmes should be provided aimed at reducing the overall adaptation cost to society. This is possible through the use of subsidies which eventually allow adjustment to occur with reduced cost to the firm or the industry. A subsidy is an aid to a polluter of all or part of the cost of the antipollution measures with which he is obliged to comply. In fact, subsidies may be of advantage in facilitating and speeding up the implementation of an environmental policy during a transitional period of adaptation.

A comparison between subsidies and the enforcement of the PPP policies reveal that the two policies have different distributional effects. In the case of the PPP the cost is borne by the producer and the consumer of the commodity in question, while in the case of subsidies, the cost is paid either by public authorities or it is shared by the polluter and the authorities. In the latter case, however, the cost of abating pollution is subsidized by a public body from revenue drawn not only from the consumers of the commodity in question, but from all taxpayers. In this respect, the subsidies policy may be preferred to the PPP because its indirect influence makes it difficult to determine who is paying and how much (Mayer, 1976).

2.2 Types of Subsidies

In this paper, we define subsidies as the various instruments or techniques actually employed in order to make a public body or international organization (or in general somebody else) bear wholly or partially the environmental-control costs rather than the polluter himself. That is, the polluter pays nothing or a part of the total pollution abatement costs. All these instruments are considered departures from the polluter pays principle, but some have less distortive impact on international competitiveness than others. The following section describes these economic instruments available for pollution control and reduction.

a. Government Capital Grants. They represent the most important and most effective form of subsidisation by the governments of productive enterprises and consist of direct financial assistance to the firm in order to reduce the capital cost required for pollution control facilities. As a result, the firm's average cost per unit of output is lower than would otherwise be the case, and its national and international competitiveness is raised.

In terms of international competitive implications, government grants are the most objectionable since they reduce the firm's per unit cost and lead to unfair competition. They are also prohibited by the General Agreement of Trade and Tariffs (GATT) in international trade relations.

Regardless of the objections, capital grants should be provided to individual firms or industries of developing countries to induce them to introduce clean and low-waste technologies in the process of implementing their environmental policy without sacrificing economic growth or other social or commercial priorities.

b. Tax Abatement. Tax relief of any kind constitutes an implicit subsidisation by governments of capital or operating expenditures related to pollution control, reduces the firm's overall tax liability, and affects positively its profitability. Tax concessions may be granted either in the form of lower corporate tax-rate or as a credit against tax liability of a certain percentage or of the entire capital investment associated with pollution control. Lower profit tax-rates should be granted for a limited time period. Usually it may not exceed the number of years required to recover the original cost of the capital investment.

Taxes employed under these two schemes may be direct (lower profit tax-rate) or indirect (i.e., tax credit against property taxes). In either case, tax abatement affects fixed costs, variable costs or the profits of the enterprise and strengthens its competitiveness in domestic as well as in international markets.

In addition, tax concessions are granted as economic incentives by all developing and many developed countries in order to attract foreign direct investment. If this is the case then taxes should also be used for pollution control investment as well.

c. Accelerated Depreciation. By writing off capital investment for environmental purposes more rapidly than otherwise, the firm effectively reduces its current tax liability and can employ the resultant savings for other productive purposes. This method is different from tax abatement because it influences the firm's fixed costs with long-term competitive implications.

On the other hand, accelerated depreciation raises the firm's profitability - at least for the depreciation period - by allowing the firm to recover the capital investment costs faster. For this reason, accelerated depreciation is one of the many economic incentives offered by developing nations to multinational corporations to increase the inflow of foreign investment in their economies. It is also used as a fiscal instrument to stimulate investments and economic growth in periods of recession.

d. Concessionary Loans. This is another way of reducing capital costs associated with pollution control. Loans may be provided to a firm either directly by public authorities or indirectly by international institutions, at rates of interest and amortisation terms more favorable than those available from financial institutions. Alternatively, government credit guarantees may be extended to the firm allowing it to borrow from other financial institutions at more favorable rates.

Both such methods lower the cost of capital to the firm and increase its profitability. Concessionary loans have long-term rather than short-term competitive implications since they influence the firm's average fixed cost. Because many developing and developed countries provide concessionary loans as incentives to attract foreign investment, they should also be provided for pollution control purposes.

e. Research and Development Expenditures. Government-sponsored research and development activity associated with environmental control may generate the necessary technical advances more rapidly and more effectively than research undertaken by individual enterprises. Once innovations have been generated, they are diffused very quickly nationally and internationally. That is, research and development benefit both domestic and foreign enterprises in meeting environmental objectives with relatively low cost especially when they are tax-financed.

As a departure from the PPP, tax-financed research and development has been recognized as an exemption and appears to be non-controversial in nature, since governments have implicitly concluded that its benefits outweigh its costs. Therefore, international competitive distortions may be minimal, because government-sponsored research and development generates innovations which become available abroad and lead to the development of industries producing pollution control products for exports (Walter, 1978).

f. Tariff and Non-Tariff Restrictions. These instruments may be employed in the case where an industry is highly trade-oriented and its competitiveness is threatened by capital investment costs for environmental purposes. Then a case can be made for the government to protect the industry in question through raising tariffs or other trade barriers for a certain time period.

Although such restrictions are inconsistent with existing GATT rules, exceptions should be made to facilitate the implementation of efficient environmental policies by the industry and secure at the same time its competitive position. In this case the full cost of capital investment is paid by the industry, but the restrictions imposed may offset the negative impact on its profitability and do not affect its pricing and output decisions. It is therefore necessary that a comparative study should be conducted to assess the benefits and costs (to the industry and to society at large) associated with trade restrictions imposed for pollution control purposes.

g. Export Premiums. Levying trade restrictions for environmental purposes, we just discussed, concerned a whole industry. On other hand, export premiums should be granted to an export-oriented individual firm who competitiveness may be jeopardized by the incremental cost of capital investment for implementing specific environmental policies.

In this specific case, the governments may provide export premiums or increase the ones already in existence to the affected firm in order to subsidize, partially or wholly, its resultant cost increase from its capital investment. The size of the premium must be equal to or a certain percentage of the incremental cost so as to minimize the negative impact of the firm's international competitive position.

h. Concessionary Leasing. This is another method of reducing capital costs related to pollution control investment. The required equipment may be purchased by public authorities and then leased to individual firms on more favorable terms than they would obtain if the firm had to acquire them itself. This is an implicit subsidisation which reduces the firm's capital investment costs due to cheaper credit available to government agencies. Leasing of capital equipment is growing rapidly in importance and may grow in significance in the future, as well.

CONCLUSIONS

At present, developing countries are confronted with two important issues. Deterioration of their environment and natural resource base and achieving sustainable economic growth. The two are totally interdependent and policies to promote both are urgently needed. These policies should be designed in such a way as to provide better linkage between economy and environment and between government and industry in reaching the goals of sustainable development.

The above problems faced by developing countries can be solved through maximum utilization of existing clean technologies which increase both economic efficiency and environmental quality. But these technologies are usually developed in industrialized countries and affordable instruments and measures should be provided to enterprises or industries in developing countries in order to be able to transfer and apply these technologies.

In spite of the difficulties encountered in estimating appropriate fee levels and administering the system, direct controls and taxes, implemented in conjunction with other policy instruments including legal requirements, can be effective in promoting the use of clean technologies, if technology options are available. It seems, however, that in most developing countries not only are there no technology options, but the existing clean technologies have not yet been introduced in these countries. What is needed, therefore, is a system of such instruments which will assist individual firms or industries in developing countries in transferring these technologies from abroad.

It is suggested that the various subsidies we have discussed in this paper are relevant and appropriate instruments to fulfill this objective. Besides, most of these subsidies - including tax concessions, accelerated depreciation, concessionary loans, and trade restrictions - are part of the package offered to TNCs by the governments of developing countries in order to attract foreign direct investment, which is the most important form of technology transfer. The same instruments must become available to individual enterprises or industries in order to assist them in the process of transferring and adopting these technologies. Despite their drawbacks, subsidies must be employed in environmental policy for reasons of social policy or regional development.

Among the various types of subsidies, capital grants for pollution control investment must be provided in cases where enterprises cannot otherwise make the necessary investment themselves without financial support. Investment grants do not simply lower investment costs, but also reduce production costs, and for that reason they should be granted to overcome temporary uncertainties and disadvantages of integrating clean technologies within enterprises. In general, grants may have a stimulating effect on the development and application of clean technologies, if the conditions in which they are to be applied are known and taken into account (ECE Seminar, 1989).

Research and development funds stimulate innovations and diffusion of clean technologies and should be directed towards long-term, internationally coordinated programmes. In this respect, many developing countries have expressed the need for improving the utilization of existing R&D centers by allocating more funds into their research and development activities. For example, Thailand has provided tax incentives for small and medium sized enterprises for the acquisition of new technologies and the establishment of science-based Parks (Expert Group Meeting, 1989).

Furthermore, many industrialized countries have set up two types of financial aid mechanisms for pollution control: direct aid for investment expenditure and antipollution operation and aid for research and development expenditure (OECD, 1985). Direct aid is granted subject to conditions which encourage the introduction of new and clean technologies. This policy, for instance, has been applied in Norway in the paper and pulp industry and in Germany in the metal-plating industry. In relation to the second category, the government finances programmes for research and development on new processes either by funding research institutes or by assisting given industrial projects. In France, for example, the Ministry of the Environment provides financial aid to industries for research and development in non-polluting, more efficient, and energy and raw-material-saving technologies. The Netherlands set up a special aid programme for clean technologies in 1975. In France and Germany, the government provides 50 percent or more of the financing for research programmes on pollution control and energy conservation.

In conclusion, developing countries should reassess, upgrade, and make more efficient the existing research and development facilities in order to strengthen their capabilities for developing, acquiring and absorbing new and clean technologies and analyzing their impact on their industrialization process. To obtain access to information and know-how in new technologies, international collaboration is required more than ever before. To this end, UNIDO's role and potential contribution becomes even more crucial and significant. It should intensify its efforts to establish information centers for the production, availability, and export of clean technologies. In addition, it should initiate the development of programmes which would assist developing countries in their efforts to develop new and clean technologies (Biswas, 1989). Such programmes would include assistance in promoting research and development activities, training of human resources, and creation of appropriate institutional infrastructure. The implementation of these programmes would strengthen the position of developing countries in negotiating, acquiring, and transferring clean technologies from international sources.

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POLLUTION PREVENTION THROUGH WASTE REDUCTION IN FLORIDA

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ABSTRACT

The 1988 Florida Legislature initiated many new and innovative waste reduction programs, which are designed to prevent pollution and to endorse the use of clean technologies and clean products. The State mandated recycling programs for paper, aluminum, plastics and glass; and set a goal of at least 30% waste reduction by the end of 1994. The State also created incentive programs to encourage the recycling of used oil, waste tires, and hazardous waste. Florida invested over $48 million in grants to local governments to initiate recycling and source reduction programs. Florida created educational programs designed to increase public awareness of the need for pollution prevention methods which achieve environmental results, which would prevent future environmental degradation, while lowering the cost of pollution control and pollution clean-up.

The Waste Reduction Assistance Program (WRAP) was created to provide a new multi-media, non-regulatory, technical assistance approach to preventing pollution. It incorporated the successful elements of the North Carolina Pollution Prevention Pays Program[1], the best components from other state programs, as well as recommendations from the U.S. Congress Office of Technology Assessment's publication, Serious Reduction of Hazardous Waste.[2]

The WRAP staff have developed a computerized Waste Reduction Information Clearinghouse to facilitate information networking between businesses needing source reduction and recycling information with vendors and possible providers of those services or equipment. Training curricula is under development at universities and community colleges to train business managers, engineers, technicians, accountants, financial analysts, insurance analysts, and clean-up crews in the incentives and opportunities for waste reduction. On-site and telephone technical assistance is available from WRAP staff, as well as the Retired Engineers Waste Reduction Assessment Partners (REWRAP). Technology transfer, promoting clean technologies and products, is achieved through industry specific fact sheets, handbooks, computer linkage, and presentations to trade and industry associations. Research and demonstration needs are being identified.

Incentives for pollution prevention are a primary focus of the DER WRAP. As a non-regulatory assistance program, we identify incentives to motivate businesses to follow. Of prime importance to the Chief Executive Officer (CEO), is the incentive to avoid becoming a JCO (Jailable Corporate Officer). Employees may mix a hazardous waste with a non-hazardous waste, such as used oil, and subsequently dispose of it improperly. A CEO can be held liable for illegal waste disposal, and perhaps lose his or

her freedom as a JCO, for the actions of a company clean-up crew. This potential risk is a major incentive for the CEO to strenuously pursue waste reduction investments while providing leadership to motivate employees.

By recognizing the successes and waste reduction achievements of businesses that practice the new environmental ethic of pollution prevention, we provide positive reinforcements for excellent corporate behavior in Florida. Through Awards for Excellence, we plan to recognize good corporate citizens so others in industry can be motivated to focus on the many opportunities to meet the environmental challenge of the 1990's – pollution prevention through waste reduction.

PREFERRED STRATEGY OF POLLUTION PREVENTION

There are basically 3 ways to deal with the problem of pollution.

1. avoid it = prevention of pollution
2. control it = strong regulations and enforcement
3. fix it later = clean-up of polluted sites.

EPA Administrator William K. Reilly has been quoted in a number of public forums as supporting strong enforcement of increasingly stringent sets of environmental regulations, as well as preventing the production of pollutants that need to be rigorously regulated. "We need to supplement our efforts with a new strategy--one that couples conventional controls and vigorous enforcement of our current laws, with pollution prevention so we can cut down on the actual amount of toxics being generated as by-products. This is one of my primary goals at EPA."[3]

Secretary Dale Twachtmann, head of the Florida Department of Environmental Regulation, has demonstrated his support of this strategy by creating what the Wall Street Journal has called "the most ambitious assault on solid waste yet attempted in any state."[4] He has endorsed waste recycling and waste reduction of all types by creating and funding innovative technical assistance and recycling grant awards. Water use reduction and water reuse programs have also been implemented. He encourages staff to "rethink old ideas and try to prevent new environmental problems from occurring. We can become part of the solution, rather than part of the problem by recycling our waste, reusing our water, and restoring damaged ecostructure." "The best strategy for protecting our environment is to prevent damage. By increasing emphasis on prevention, more air, water and land resources can be saved from degradation; and the environmental, economic, and political costs of regulation, restoration, and mitigation can be avoided." (DER Mission and Philosophy).[5]

Preventing waste often has a payback of investment of less than 6 months. Waste reduction of air toxics and RCRA regulated hazardous wastes of 50 to 90% have been achieved in several companies with top level management commitment to pollution prevention. In-plant recycling and reuse of water has lead to significant reductions in wasted water for rinsing and cooling operations. By reducing the volume of discharge to wastewater treatment plants, waste reduction can in effect "add capacity."

If business dollars and human resources are invested in a comprehensive multi-media air, water, land approach to reduction of water wastes, air toxics, solid wastes, RCRA regulated hazardous wastes, non-regulated potentially hazardous wastes, and energy wastes--then less taxpayer dollars are necessary over time for the cleanup of contaminated sites. As more wastes are reduced, the allocation of the essential state regulatory resources can be focused on the "bad guys" that have no interest in protecting our environment. When pollution is prevented there will be an extension of the life of very hard to site waste treatment and disposal facilities.

Our 20 years of end-of-pipe regulation of pollutants has created an enormous economic burden which still does not achieve the environmental results intended by our various pollution control regulations. Industry and government spend at least $70 billion per year on regulatory compliance and enforcement, with each new page of regulations costing an estimated $1,000,000 per page to implement. We must continue to have strong regulations and enforcement, but we should go back upstream to the "beginning-of-the pipe" and reexamine what pollutants we are using at the source of operation. We need to rethink our inputs and outputs of manufacturing processes or repair operations. We need to reduce waste at the source by modifying processes, using less toxic input materials, improving our operating practices, and managing our inventory so that we don't have to discard unused toxic materials. We should aim to recycle anything and everything possible by segregating waste streams to allow recycling, while making it easy for individuals to make the personal decision to reuse it and recycle it.

Concerning efficiency of allocation of limited public tax dollars as well as business investment dollars, there is no doubt that preventing a problem is preferable in the short term and long term.

In terms of effectiveness of these three approaches, pollution prevention is of strategic advantage also. The issue of "How clean is clean?" pervades clean-up actions as well as regulatory enforcement issues. Once a pollutant is released into the environment, it is typically dispersed, at some rate, so total capture of all of it is practically impossible and/or extremely expensive. If you prevent the pollution, it doesn't have to be regulated or cleaned up later, because the problem is simply, effectively and efficiently avoided from causing any environmental degradation.

We as individuals are responsible for generating the mountains of garbage, millions of gallons of wasted water, tons of hazardous wastes, hundreds of pounds of air toxics and other air emissions. We use the products of commerce and discard a huge waste stream every year. Business, industry, government, educational institutions, and we the public are part of the waste management problem and we all need to become part of the solution to pollution. We can do this by emphasizing the prevention of pollution through waste reduction.

We support the preferred waste management hierarchy of:

First - Reduce it at the source of generation
Second - Reuse it as long as possible
Third - Recycle everything you can
Fourth - Treatment to detoxify or recover energy
Fifth - Disposal as the last resort.

Through pollution prevention strategies, we can increase the efficiency of actions of our human resources in preventing the degradation of our environment. We can enhance the effectiveness of our environmental protection efforts. We will enhance the economic savings of taxpayer dollars and business investments. We will achieve the environmental results we are all working toward. An ounce of pollution prevention is truly worth a pound of clean-up "cure".

THE MAGNITUDE OF THE POLLUTION PROBLEM IN FLORIDA

Florida has 13 million residents and over 26 million visitors each year. An estimated 900 new residents move to Florida each day. Over the course of the year, this is equivalent to adding a city the size of Tampa each year. Almost 16 million tons of municipal solid waste were generated in Florida in 1988, and less than 4% of that waste was recycled. The highest points in Florida are mountains of garbage, sometimes referred to locally as "Mount Trashmore."

Paper is the majority of the solid waste created, estimated at around 40%. Food composes 10%, wood wastes are 6% and yard wastes are around 15% of the waste amounts. Metals are 6%, glass is around 5%, and plastics compose about 9% of the waste. All of these wastes have a huge potential for recycling.[6]

Other special wastes that need special handling, but until recently may have been disposed in solid waste landfills each year around Florida include:

. Millions of tons of construction and demolition debris
. 200 to 400,000 tons of biohazardous wastes
. 120,000 tons of household hazardous wastes
. 150,000 tons of small quantity generator hazardous wastes
. 4 million used lead-acid batteries
. Unknown amounts of small batteries containing Mercury, Lead, Cadmium,
  Nickel and Lithium
. 600,000 tons of ash from the waste-to-energy plants that combust 21% of the waste stream
. 15 million used tires (2% of all solid waste)
. 7 million gallons of used oil from Do-it-Yourself auto mechanics
. 3 million appliances (white goods)
. 10 to 14 million pieces of discarded furniture.

Most of the old solid waste landfills in Florida are unlined. Many are located in sandy soil in an area with a high water table. The Department's Solid Waste Section has created rigorous new landfill liner and leachate control system requirements that have increased the cost of new permitted landfill space to $175,000 per acre or higher. However, at least 41 old leaking landfills are targeted for clean-up. More than 1,000 sites in Florida have been identified for an analysis of contamination.

As many as 80,000 small businesses may be conditionally exempt or small quantity generators of regulated hazardous wastes and potentially hazardous wastes (used oil and lead-acid batteries). An estimated 550,000 tons of oils, solvents, heavy metals, paints and batteries are created by these businesses each year. Large quantity generators of hazardous wastes create around 500,000 tons per year. Around 24 million gallons of used oils and lubricants are created by businessmen each year, with at least 70% of that oil being burned as a fuel substitute for virgin oil.

According to the Toxics Release Inventory data[7] required by SARA Title III, at least 53.2 million pounds of fugitive and stack emission air toxics are released in Florida by the businesses required to report this data. Vapor degreasers are used in many businesses and industries for parts cleaning prior to electroplating or painting, printed circuit board manufacture, parts repair, and other operations. Our observations from on-site technical assistance indicate that many of these large heated vats of hazardous solvents are left open continuously and are wasting 30 to 50% of the solvents to the air. Many of these are in ozone non-attainment areas for air quality in the lower east coast metropolitan area as well as other large cities with air quality non-attainment areas.

The condenser coils on these vapor degreasers are often not operating correctly so millions of gallons of fresh water are dumped needlessly into wastewater treatment facilities. This inefficiently wastes fresh water and capacity from much needed Publicly Owned Treatment Works (POTWs). Reusing this fresh water from the condenser coils for makeup water in electroplating rinsing baths prior to discharge could "add capacity" to POTWs and reduce overall water use. Reuse of reclaimed water for industrial operations can help reduce the use of potable fresh water needed for drinking water supplies. Water reuse at over 200 projects in Florida now saves 320 million gallons per day.[8] In an era of growth management controls and concurrency requirements in Florida for economic development and infrastructure needs, the multi-media approach to reducing wastes of all types could help provide waste management, fresh water supply, and wastewater treatment capacity efficiency gains to respond to the needs of new growth caused by Florida's 900 new residents each day.

THE 1988 SOLID WASTE MANAGEMENT ACT

The 188 pages of legislation contained in this Act[9] are very comprehensive and far reaching in scope. This aggressive attack at preventing more of Florida's huge mountains of garbage and rapidly filling landfills has made a difference in its two years of enactment. Over $48 million in recycling grants have been provided to all 67 counties in Florida, as well as many cities. The first year of funding included $18.5 million in Oil Overcharge Funds, provided by the Governor's Energy Office. The remainder came from new fees on tires ($1/tire), newspaper ($.10/ton), sales tax registration fees and changes in the sales tax collection allowance procedure.

The primary goal of this ambitious assault on solid waste is to achieve an overall recycling rate of 30% by the end of 1994. Almost 75% of Florida's 16 million tons of solid waste was disposed in 170 permitted landfills. Many of these landfills will be closed over the next 3 years since they do not meet new stringent landfill liner requirements. Florida's nine waste-to-energy facilities combusted 21% of the total waste stream in 1988, and only 4% was recycled.

A "three thirds" strategy is endorsed to increase recycling to a third, add waste-to-energy capacity to manage a third (and provide needed new electrical capacity to substitute for coal fired plants), and reduce the amount landfilled from 75% down to a third or less.

Recycling grants have been awarded to all 67 counties and many cities initiating solid waste recycling programs. First year funding included $4 million for educational programs, $1 million for waste tire recycling and management, $1 million for used oil recycling, and $750,000 to reward 40 local governments who had recycling programs in place before it was required by law. "Truth-in-garbage" now requires full cost accounting to reflect all costs of waste management. Recycling education guidelines and programs are required.

While providing the funding for these innovative recycling and education programs, the Department also prohibited landfill disposal of used oil, lead-acid batteries, white goods, used tires, and construction and demolition debris at a variety of deadlines before 1995.

Recycling incentives were established to encourage the use of clean products and technologies. The Florida Department of Commerce is charged with assisting recycling business startups and expansion. A sales tax exemption is available for the purchase of recycling equipment and machinery, if it consumes not less than 10 percent of Florida-source recyclable materials. The Act also established roles for various state agencies to encourage recycling and use recycled goods in their operations. A 10% bid preference is to be provided for the purchase of recycled paper and other products by state or local governments. A 5% bid preference for the use of used oil is also provided to stimulate the market development for purchase of products made from recycled goods.

There are many other Act requirements of far reaching consequences for the treatment and disposal of wastes in Florida. However, our purpose is to focus on pollution prevention through waste reduction; which includes source reduction, reuse, and recycling. Further details of the excellent progress on the requirements of the comprehensive Solid Waste Management Act, the associated rules and innovative programs, can be provided by the DER Solid Waste Environmental Administrator, Bill Hinkley.

SOLID WASTE RECYCLING ACTIVITIES

As of March, 1990 at least 20 of 67 counties had implemented a Residential Curbside Pickup of recyclables. These counties contain 82% of Florida's population. Residential drop-off programs were in 17 counties. The "minimum four" recyclables are defined as newspaper, aluminum cans, glass, and plastic bottles. At least 50% of these wastes must be recycled by the end of 1992, or a one cent per container "advanced disposal fee" is imposed. If this goal is not achieved by 1995, the fee increases to two cents per container. Only seven cities and 10 counties were recycling all of these by the end of the first year of the grant program. Newspaper was collected for recycling by 46 cities and 26 counties. Aluminum cans are recycled at a rate of almost 50%, with programs in 28 cities and 25 counties. Plastic bottles are collected at only 6 cities and 11 counties. Yard trash is collected at least in five cities and five counties. At least 42 counties have achieved a positive recycling rate. Participation rates for the second year will surely increase as recycling education expands in local and state government agencies.

Recycling in apartments, condominiums, and commercial establishments has only just begun, but is a source of huge potential for recycling in Florida. State agencies are now initiating recycling programs for aluminum cans, newspaper, office paper and computer paper. For two years DER employees have collected these recyclables, saving 142.75 tons of paper, which represents an estimated 2368 trees, as well as 3251 pounds of aluminum.

Recycling markets are very important to the long term success of any waste collection program. DER conducted a survey of 242 potential dealers and processors of wastes to be recycled. Industrial and commercial sources accounted for 58% of the 1.6 million tons of recyclable materials collected in 1986. Private individual non-profit groups collected 29% of this tonnage. Municipal programs only contributed 3% in 1986, prior to the new initiation by the 1988 Solid Waste Management Act. If we are to make significant recycling progress, governments must become a steady market for recycled goods. DER now uses copy machine paper and writing paper with recycled paper content. If we are to prevent pollution, we must individually and collectively choose to reduce, reuse, and recycle anything and everything we can.

THE MULTI-MEDIA WASTE REDUCTION ASSISTANCE PROGRAM (WRAP)

The Waste Reduction Assistance Program is a cooperative NON-REGULATORY, multi-media, technical assistance approach to helping businesses, industry, local governments and educators prevent pollution in Florida. We provide a set of "fresh eyes" to help a business person identify all types of waste reduction opportunities in their facility. The value of creating a multi-media air, land, and water approach is that pollution is not just controlled, concentrated, and moved from one media to another. Examples of multi-media transfer of regulated concentrated pollutants include: heavy metals in wastewater sludges moved from water to land disposal; or removing air pollutants from combustion and disposing on land; or burning petroleum or solvent contaminated soil and exhausting air pollutants. If you go back to the source of the pollution, you prevent the problems of the "end-of-pipe" regulations. Since regulatory requirements are a moving target, becoming steadily more stringent we must aim to optimize the use of business dollars to comply with environmental regulations, but reduce all wastes to the extent possible, whether they are regulated today or not. The economic competitiveness of our businesses and the economic survival of our democratic governments depends on efficiency gains and effective use of diminishing financial resources.

Waste reduction can save millions of dollars in pollution control expenditures and millions more in subsequent pollution clean-up costs. By not generating a particular hazardous waste, a business can avoid the cradle-to-grave liability that results from the generation of hazardous waste. Reducing waste prevents pollution, it increases efficiency of a business's operations, and results in lower raw material and labor costs. Waste reduction achieves positive environmental results.

The Waste Reduction Assistance Program emphasizes efforts to reduce waste at the source, followed by environmentally sound on-site and off-site recycling. Assistance in reducing hazardous wastes, solid wastes, air toxics, wasted fresh water, waste water discharges, and energy wastes is provided. For the remaining wastes, there will be a need for proper waste management. But even then, there are opportunities for reducing the volume or toxicity of wastes, depending on the methods of treatment chosen. As a last resort, the remaining hazardous wastes should be disposed of properly.

The Waste Reduction Assistance Program consists of seven components:

1. Information Clearinghouse
2. Training Curriculum
3. Technical Assistance
4. Research and Demonstration
5. Technology Transfer
6. Incentives for Pollution Prevention
7. Awards for Excellence

THE WASTE REDUCTION INFORMATION CLEARINGHOUSE

The Waste Reduction Information Clearinghouse is a computerized information clearinghouse which is designed to include: contact persons in local, state and federal government; trade and professional associations; schedules for technology transfer workshops and conferences; information on waste reduction technologies; recyclers, equipment vendors and pollution prevention service companies. The information clearinghouse also will provide case studies of successful waste reduction efforts of Florida businesses as examples of the benefits of waste reduction. Free copies of waste reduction publications are provided to educate all sectors of society.

TRAINING AND TECHNICAL ASSISTANCE

The Waste Reduction Assistance Program is currently managing a U.S. Environmental Protection Agency grant through the University of Florida's Training, Research, and Education for Environmental Occupations Center. The purpose of the grant is to determine Florida's training needs in the areas of waste reduction and waste management for the next 5 years. Once this is completed, the Center will develop the actual curricula for waste reduction and waste management courses for engineers and technicians. Business managers, accountants, financial and insurance analysts and clean-up crews are future targets for training curricula. The Used Oil Recycling Education and Incentives Contract with Valencia Community College has produced curricula aimed at educating science teachers, kindergarten and first grade students, middle and high school students, and community college students on the value of recycling used oil to prevent pollution of Florida's water supply. A contract for general and industry specific Pollution Prevention Education modules is under development.

Presently, the Waste Reduction Assistance Program is conducting an aggressive technical assistance and training program. Program staff have provided on-site technical assistance to at least 64 waste generators and to thousands of businesses over the telephone. Waste reduction assessment training has been provided to environmental inspectors in Dade and Broward counties. The county employees who received this training will provide waste reduction information and assistance to an estimated 6,000 Dade and Broward businesses annually. Other county staff have also received training, and future training opportunities will be available.

TECHNOLOGY TRANSFER AND INCENTIVES

The Waste Reduction Assistance Program is also spreading the message of pollution prevention through waste reduction at meetings of industrial and professional groups, such as the Florida Chamber of Commerce Solid and Hazardous Waste Management Short Course and Trade Show. [10] Following these meetings, those who attend are able to bring home the message through a series of industry and waste specific fact sheets and handbooks that the WRAP distributes free of charge.

Environmental Education to all segments of Florida's population is a goal of the WRAP. We aim to publicize the incentives to motivate people to prevent pollution. People create hazardous wastes through their purchase, use and discard of hazardous substances. By purchasing less toxic products, or choosing not to purchase services that create hazardous or solid wastes, individual consumers can prevent pollution and protect our water supply.

One of the incentives for a Chief Executive Official (CEO), such as a company who generates hazardous wastes or used oil, is to avoid becoming a Jailed Corporate Official (JCO). In Florida, a large network of different types of law enforcement officers are intensifying enforcement of environmental laws. If the person who takes out the garbage illegally disposes of a hazardous waste, the CEO can become a JCO. By publicizing the economic and good publicity incentives to business managers, we plan to motivate CEOs and environmental managers to volunteer to receive on-site assistance. When they make a personal commitment to waste reduction it will happen.

AWARDS PROGRAMS

The WRAP wants to recognize successes through the Awards for Excellence. In 1989, DER's Southeast District conducted an award program in conjunction with The Southeast Florida Industrial-Environmental Association in which Secretary Dale Twachtmann presented the Hazardous Waste Management Awards. In 1990, the Secretary presented the Environmental Awards to five outstanding projects.

TARGETS FOR WASTE REDUCTION

More than 75% of the hazardous waste produced in Florida is from these types of small and medium sized businesses, which are WRAP's primary technical assistance targets.

- Automobile repair and transportation services,
- Construction and building repair,
- Medical and other laboratory services,
- Printing and communications activities,
- Metals manufacturing and finishing,
- Dry cleaning and cleaning services, and
- Boat building and repair.

USED OIL RECYCLING ACTIONS

Florida's Solid Waste Management Act created many new initiatives for used oil collection, management, transportation and recycling. The Waste Reduction Assistance Program staff promote increased recycling through grants to local governments and recycling education actions.

Used Oil Collection Center Grants

The Legislature provided $1 million in grants to local governments to establish public used oil collection centers. By June 30, 1989, fifty-four counties, six cities, and the Miccosukee Indian Tribe were awarded between $4,000 and $25,000 in grant funds to provide over 200 public used oil collection centers, and public awareness programs to encourage recycling of used oil. Private petroleum retail operations have volunteered to accept used oil from the public at over 370 Florida locations. The law requires a prohibition on land and water disposal of used oil, as well as establishment of a 5% price preference for purchase of recycled used oil by state and local governments.

Used Oil Recycling Education

A $1.5 million contract with Valencia Community College will deliver:

- A report on Used Oil Recycling Data.
- Educational materials for Petroleum Product Retailers of Used Oil.
- A Local Government Used Oil Recycling Program Guidebook.
- A Retail Outlet Used Oil Collection and Recycling Center Booklet.
- Used Oil Recycling Awareness and Incentives Promotional Materials.
- A Used Oil Recycling Education Teacher Training Curriculum Package.
- Used Oil Procurement Guidance for State and Local Governments.

POLLUTION PREVENTION PARTNERS

The Waste Reduction Assistance Program has implemented an activity called the Retired Engineers Waste Reduction Assessment Partners (REWRAP). These Pollution Prevention Partners have provided waste reduction technical assistance for many Florida businesses. The part-time retired engineers and two more than full-time waste reduction engineers have initiated help to over 64 Florida businesses. They have already assisted businesses such as electroplaters, painting operations, boat builders, automotive repair, jet turbine repair, printed circuit board manufacturers, and local government facilities reduce their generation of wastes. The types of wastes identified as candidates for reduction include hazardous wastes, solid wastes, used oil, air toxics, wasted water, and energy wastes. This free non-regulatory help is available by calling any WRAP staff member.

CONCLUSION

Significant waste reduction can be achieved by rethinking industrial process designs and retraining governmental and business waste managers to focus on pollution prevention opportunities. Many of these opportunities are low or no-cost alternatives to increasingly expensive pollution control methods. When pollution is prevented, long term liability exposure is reduced, worker exposure to toxins are reduced, taxpayer expenses for clean-up are avoided, and Florida's environment is protected.

The Florida Waste Reduction Assistance Program was created to provide non-regulatory information transfer and technical assistance to help people make a choice concerning waste reduction opportunities. The future choices are ours. We can prevent the problem of pollution. If we prevent it, there is less control and treat to detoxify. The probability of future clean-up costs is dramatically reduced with waste reduction. You and I can make a difference in saving our planet. **Use it again! Reduce -- Reuse -- Recycle!**

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A RIDE THROUGH SPACE - WITH CARE AND CONCERN

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Most of us forget, as we sit in this room that we are traveling through space at a speed of approximately 67,000 mph. This is just the speed of our orbital velocity around the sun. We are also spinning on our own axis, and then in addition we have our own galactic motion as our universe expands. When you realize that we have billions of stars like our sun in our galaxy and then there are probably billons of galaxies, you reach the conclusion that planet earth is a pretty small spaceship gliding through the dimensions of both space and time and we are merely passengers.

We, of course, do not know whether we are unique or not, which is something we are continuously striving to find out. However, the things we do know are that we exist, that this is our planet and solar system, and that if we want to continue on this grand ride thru space and time, we have to make sure that our spaceship is kept in good shape.

This is probably not the best of examples, but I bring space into it, because of the importance that space, and especially the space that is within the gravitational field of our earth, is to us. It is part of the earth system.

My major area of discussion, today, is the Engineers concern for the environment, and the responsibility that Engineers have to society to ensure that our planet earth, our spaceship, remains in such a shape that not only we, but future generations can enjoy the ride. Unless we somehow blow it up, our planet is going to continue spinning through space for several billions of years. What mankind will look like and act like at that time is difficult to predict, but what is important to us here today is that we exercise the care and concern needed now that will protect our planet so that mankind can continue to evolve and revolve.

"Care and concern" are beautiful words. They connotate responsibility. They imply a compassionate nature. I hope they imply that the Engineering profession recognizes a primary responsibility to the welfare, health and safety of the community.

As we approach the 21st century, we are increasingly aware of the tremendous complexity of the interaction among development, technology and social forces. There have been tremendous achievements and advancements in our development of technology; yet the application of this technology requires us to also recognize the destructive nature of some of this technology, if not applied with care and concern for the downstream consequences.

I am a believer in development. I see most of the infrastructure on this planet as a positive force in our everyday lives. I am not a believer that man should exist on this planet and leave no foot prints. However, care and concern should be exercised so that they are good foot prints. Proper development, or possibly sustainable development are better words, requires that we Engineers adhere to an Environmental Code of Practice that sets forth guidelines that promotes "sustainability". Codes of practice, are at best, fraught with difficulty. There are both national and regional differences in methods of the practice of engineering, and particularly business practices. But from moral and ethical points of view, when environment is the basic subject, there should be and can be only one approach. This approach has to be based on personal values that govern decision making and these personal values have to be universally shared.

An approach to such a code has been undertaken by the World Federation of Engineering Organizations (WFEO). This is a global-wide umbrella organization for the leading engineering organization in each of 85 countries. It represents millions of engineers around the globe and one of its basic objectives is to encourage the application of technical progress for the economic and social advancement of the peoples of the world.

One of its committees, the Committee on Engineering and Environment developed a Code of Environmental Ethics for Engineers during 1983-1985. It was mainly the brain child of Engineers from Argentina and Venezuela, but it was reviewed by members of the committee from about 20 countries and then inturn adopted by the entire WFEO in 1985.

It states that man's enjoyment and permanence on this planet will depend on the care and protection he provides to the environment, and lists seven major principles which all Engineers should follow. These are:

"When you develop any professional activity:

1. Try with the best of your ability, courage, enthusiasm and dedication to obtain a superior technical achievement, which will contribute to and promote a healthy and agreeable surrounding for all men, in open spaces as well as indoors.

2. Strive to accomplish the beneficial objectives of your work with the lowest possible consumption of raw materials and energy and the lowest production of wastes and any kind of pollution.

3. Discuss in particular the consequences of your proposals and actions, direct or indirect, immediate or long term, upon the health of people, social equity and the local system of values.

4. Study thoroughly the environment that will be affected, assess all the impacts that might arise in the state, dynamics and aesthetics of the ecosystems involved, urbanized or natural, as well as in the pertinent socio-economic systems, and select the best alternative for an environmentally sound and sustainable development.

5. Promote a clear understanding of the actions required to restore and, if possible, to improve the environment that may be disturbed, and include them in your proposals.

6. Reject any kind of commitment that involves unfair damages for human surroundings and nature, and negotiate the best possible social and political solution.

7. Be aware that the principles of ecosytemic interdependence, diversity maintenance, resource recovery and interrelational harmony form the bases of our continued existence and that each of those bases poses a threshold of sustainability that should not be exceeded.

Always remember that war, greed, misery and ignorance, plus natural disasters and human induced pollution and destruction of resources, are the main causes of the progressive impairment of the environment and that you, as an active member of the engineering profession, deeply involved in the promotion of development, must use your talent, knowledge and imagination to assist society in removing those evils and improving the quality of life for all people."

These are grand principles. You may word them differently, but they can be practiced universally.

And, of course, this is not the only "Code of Ethics" that exists. As an example, the Institution of Engineers, Australia, has developed an "Environmental Code of Practice" which embodies many of these same principles. New Zealand has done the same. And in discussions with the Engineering Directorate of UNESCO, they are working diligently to develop an Environmental Code to which they hope the Universities around the globe would require their engineering graduates to subscribe. They, UNESCO, would like to develop an Oath of Practice similar to the medical profession, for environmental engineers.

In concluding my remarks, today, I would like to quote from the Introduction to a pamphlet entitled "A Study of Global Change" prepared by the International Council of Scientific Unions.

"Mankind today is in an unprecedented position. In the span of a single human generation, the Earth's life-sustaining environment is expected to change more rapidly than it has over any comparable period of human history. Much of this change will be of our own making. Worldwide economic and technological activities are contributing to rapid and potentially stressful changes in our global environment in ways that we are only now beginning to understand. The effects of these changes may profoundly impact generations to come."

How effectively the engineering profession, along with the scientific community and the public at large, respond to the environmental care and concern challenge, will govern the quality of our ride through space.

ORGANIZATIONAL BEHAVIOR AS A KEY ELEMENT IN WASTE MANAGEMENT DECISION MAKING[1]

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ABSTRACT

Given that pollution prevention often benefits both the firm and the public, we might expect rapid and complete implementation of waste reducing technologies and work place practices. However, implementation levels are lower than is economically rational. Energy management, like pollution prevention, is a process waste management problem with both technological and behavioral elements which organizations generally accord relatively low priority. To explore why the same apparent irrationality occurs there, I conducted interviews and used archival records to compare four universities' energy management and organizational histories.

The options the universities pursued differed surprisingly in their form, extent, and timing. While the schools' size and relative emphasis on science accounted for some of the variation, two key variables, the ability of specialist managers to acquire and analyze information and the distribution of power and incentives, appear to constrain institutions' capacities to identify and implement solutions. With objectives accorded low priority, these seem to be very sensitive to variations in organizational structure. For example, the most decentralized university very successfully implemented behavioral solutions, which require high incentives and low technical information processing capacity, but had less success with complex technical ones.

Ongoing work and discussions with regulators and litigants of polluters indicate that this model applies well for pollution control.

The results suggest that effective pollution prevention policy modifies either technology or organizations. In particular, three classes of policy are envisioned. One encourages development of more adoptable technology, the second aims to eliminate constraints within organizations, and the third seeks to change the priority organizations accord the problem.

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[1] I am indebted to Bob Thomas and Kathy Porter for their assistance with the argument and structuring of the discussion respectively. Andy King, Yiorgos Mylonadis, and Chris Schabacker provided valuable comments. This research was sponsored by the MIT Physical Plant Department.

INTRODUCTION

The Bush administration's commitment to market-based pollution policy assumes that abatement is inhibited principally by the lack of a clear market signal. Economic signals will foster far greater implementation levels than command and control regulations. This assumes that firms' internal dynamics are a relatively minor obstacle to pollution prevention. In this paper, I will argue that, on the contrary, in many firms, especially those which accord pollution control a relatively low priority, internal obstacles overwhelm decision-making, to favor end-of-pipe solutions. Consequently, correct external incentives are a necessary, but grossly insufficient condition for effective policy.

Many waste reduction projects benefit both the firm and the public. The firm can increase its efficiency of operation and save money without increases in management complexity (1). The public is exposed to a smaller, less hazardous, waste stream. Therefore, a smoothly operating market would provide rapid implementation of waste reducing technologies and work place practices which are currently profitable. However, levels of implementation are much lower than is economically rational (1).

Institutional energy conservation provides an excellent laboratory to explore the market's ability to produce waste reduction behavior. Energy conservation is a form of waste reduction, but, has several advantages over pollution prevention as an object of study. First, the consumer faces a clear price signal. The market is much closer to perfect than we could ever expect in pollution control. Thus, we get a good opportunity to see the market in action. There is significant evidence that implementation levels of energy conservation technologies are much lower than is economically rational (e.g. (2),(3)). Second, energy conservation is a problem of relatively long duration. The first "energy crisis" was in 1973, followed by a second price shock in 1979. By the time the study presented here was carried out (1987-'88), people had been pursuing conservation for fourteen years. Therefore, we can eliminate startup effects. Third, many options are relatively standard. This facilitates inter-organizational comparisons.

Given that rational choice models do not appear to explain institutional behavior, alternative explanations of decision making are needed. In this paper, I will draw from organizational theory to present and discuss data from an exploratory study into institutional obstacles to energy management in four universities. I made no prior hypotheses as to why universities might be poor decision makers, other than that it may be related to organizational factors. This very open-ended approach was selected because, at the time, virtually no obviously relevant literature was available.

The findings which emerged can be understood on two levels. At the first, two variables appear to be critical to understanding organizational decision making. They are 1) the information gathering and analysis capacity of the people charged with formal responsibility for energy conservation, *vis a vis* the information gathering and analysis requirements implicit in a given solution, and 2) the power these people have, through coercion or incentives, over the people whose cooperation or support is necessary for successful implementation of a given technology, versus the amount needed for that technology. At the second level, the structure of the organization and its institutional environment very strongly prejudices managers' abilities to command all the information and power needed for a given solution. When energy conservation or pollution prevention is accorded a relatively low priority, specialist managers are, in general, relatively peripheral. The solutions they develop map onto the rest of the organization's technology as the specialist managers map onto the rest of the organization. That is, they favor the solutions which are least constrained by power and information. These are generally add-ons to the organizations' core technology, for pollution control, this often means end of pipe technologies.

METHOD

The research was guided by a recognition that organizations have a multitude of options available for the management of energy. The key question was whether the nature of the organization told us anything about the choices that were made once people chose to act. That is, in what way does the nature of the organization delimit the smorgasbord of economically feasible options to the small subset from which the organization actually selects?

Data was collected primarily through seventy-five interviews of 60 to 90 minutes duration and from archival records at four sites; the two universities discussed here, a major state school, and a medium sized private one. Key interviews were transcribed. I aimed to obtain histories of the organization, energy management, and relevant events outside the university. I also sought to understand current practices, including equipment maintenance and replacement procedures, the way energy conservation was incorporated into new buildings, and the way energy managers interacted with both users and various people responsible for physical facilities.[2] Where these practices had changed over time, I also examined their evolution. I solicited information and opinions from all management levels from first level supervisors through to, generally, the vice presidential level, or equivalent. Where possible, I interviewed users. I also interviewed architects, shared savings contractors, HVAC engineers, and union officials, in person or by telephone.[3]

For brevity I will focus on two representative examples of energy management decisions - computer controllers and light bulbs - from two sites. Although many more decisions were studied,[4] these two are particularly appropriate for several reasons. First, these technologies are considered the linchpin of effective conservation. That is, they are particularly cost effective. Second, they are polar opposite approaches: compact fluorescent bulbs are very cheap, simple, and present in the work-place; computer controllers have historically been very expensive, complex, and hidden in the university's infrastructure. Third, neither impedes, to any significant extent, the quality of the academic environment. (In fact, computer control tends to make it more comfortable.) Therefore, implementation buffers the organization's core from the, potentially disruptive, environment (4). Fourth, both the light bulbs and the controllers are cheaper and easier to manage, once installed, than their predecessors. Hence, virtually always, they are an unambiguously good idea. Finally, these solutions are not mutually exclusive. Installing one does not affect the other's feasibility.

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[2] By energy manager, I mean members of the organization who make energy conservation decisions as economic agents.

[3] Once it was developed, I tested the model's validity by presenting it to activists and government agencies who study pollution behavior to help, regulate, or sue organizations. No one disagreed with the model.

[4] These include motor and fan retrofits, computer control operations, building envelope retrofits, rationing, fume hood controllers, and preventative maintenance. The data is presented in full in (5).

In the following sections, I will compare and contrast decision making in the two cases at the two sites and attempt to explain each university's decisions. After contending that the explanation can be generalized beyond energy management in universities, I will discuss some policy implications.

TWO SITES: TECH-U AND PROF-U

The first site, Tech-U, has built its reputation through its strength in the applied physical, biological and social sciences. The other, Prof-U, also a private university, is famous for its professional faculties. They are matched in every respect except student type and organizational structure. They have virtually identical weather, investment criteria, and ready capital availability. Both have multiple, virtually independent, campuses. I examined only the main one, which was about the same size in each case. Energy conservation was considered important by those responsible for it, though only in one case did senior management make it a faculty priority. Both universities have been reasonably successful energy conservers. Tech-U was a successful early implementer of direct digital control, and one faculty at Prof-U halved energy use between 1980 and 1985.

Their organizational structures differ.[5] Tech-U is administratively uniform with its different schools using centralized administrative resources. Facilities services are provided by a centralized Physical Facilities Department (P.F.D.). As would be predicted by organizational theory (4) energy management is the responsibility a specialist office separate from the organization's core, the operations division of the P.F.D.

Prof-U, on the other hand, is comprised of ten autonomous faculties. Each manages its own endowment, tuition, and expenditures. Each faculty's facilities office purchases services from either the university's Buildings Maintenance Department (B.M.D.) or outside vendors. In the study, I examined the major School for Arts and Sciences (S.A.S.) and a Small Professional School (S.P.S.). The S.A.S. had about fifteen people overseeing a part-time army of superintendents (who liaised with the B.M.D. mechanics) and energy monitors[6] (who dealt with users). The S.P.S. had a facilities office of three people devoting up to three half-days a week each to facilities. This splitting of responsibility necessitated splitting the energy management task between appropriate people in the facilities offices and in the B.M.D.[7]

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[5] Centralization differentiates these two sites. Using different pairs of universities, I could make the same argument around other structural variations such as delegation, external contracting, etc.

DATA

The obvious way to examine the research question is by studying which solutions the given organizations did or did not implement. However, this approach would miss two very important elements of the data: the timing of decisions and extent of implementation of solutions. In some cases, implementation was virtually simultaneous with introduction of a technology to the market. In others, there were lags of up to twelve years. If lags occurred, action was generally precipitated by a (generally external) event. Hence, timing is best understood using a binary variable: the existence, or not, of a significant lag.[8] Second, all sites attempted virtually all options at one time or another. However, their success varied. Therefore the other indicator of performance became extent of implementation (proportion of climate controlled buildings retrofitted). (Table 1)

As Table 1 shows, implementation of these two technologies was far from uniform. Tech-U was a very rapid implementer of the centralized direct digital control computer control systems (DDC) which came to market in 1976 (it was actually a prototype site) and it upgraded the system in a timely manner as new technology became available. For compact fluorescent lightbulbs, however, which are much simpler and cheaper, the lag was relatively long, three years. In contrast, while the B.M.D. at Prof-U had installed a simple supervisory computer control system in the early 1970s to turn systems on and off daily, it failed to consider the next generation of the technology when making system upgrades. Furthermore, the two faculties did not actually use the supervisory computer for energy conservation until 1980 and 1986 respectively. Finally, only after the faculties started installing cheap and powerful microcomputer-based DDC systems did the B.M.D. consider how it would accommodate them.

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[6] A position held by an administrator in the relevant building.

[7] At various times, this responsibility was shifted around in the S.A.S. at Prof-U. From 1973-'79, the Dean took principal responsibility and two people in the facilities office worked on selected problems. From 1980-'85, when energy use was cut 50%, he and the engineering professor who catalyzed the initiative co-chaired an energy management oversight committee. He also expanded the facilities office's energy management staff. At the initiative's end, in 1985, the facilities office assumed responsibility and used an incentive program to move some of the onus to individual buildings.

[8] Whether or not a lag is significant depends on the nature of the solution. Longer delays can be expected for expensive and complex solutions.

TABLE 1. EXTENT AND LAG OF IMPLEMENTATION FOR COMPUTER CONTROL AND COMPACT FLUORESCENT LIGHTS

	First Mkted	Tech-U			Prof-U								
		P.F.D.			B.M.D.			S.A.S.			S.P.S.		
	Yr	Yr	Lag (Yrs)	Bldgs (115)	Yr	Lag (Yrs)	Bldgs (No)	Yr	Lag (Yrs)	Bldgs (175)	Yr	Lag (Yrs)	Bldgs (6)
Centralized D.D.C.	1976	1976	0	34	*			N/A			N/A		
		1978	#	50									
Microcomputer based D.D.C.	1984	1987	#	A/A	N/A			1984	0	4	1986	2	1^+
Scheduled control systems	N/A	1976	3	34	N/A			1980	7	A/A	1986	13	6
		1978	#	50									
		1987	#	A/A									
Compact fluor. lightbulbs	1984	1987	3	A/A	N/A			1984	0	A/A	1986	2	1^+

* Action not taken by 1987/88

# Lag not relevant once other actions are considered

N/A Action not appropriate for this organization or part thereof

A/A All appropriate buildings. At Tech-U, for computer control, this was about 65 (excludes dormitories, unconditioned buildings, and those a great distance from the campus). For compact fluorescent bulbs, about 100 buildings. In the S.A.S. at Prof-U, for computer scheduling, about 100 buildings, and for lights, extensive changes in 15 buildings and minor changes in many others.

+ Services purchased through shared-savings contract

This pattern was repeated throughout. Tech-U was a much better implementer of complex, expensive, technical solutions which did not require interactions with users (e.g. preventative maintenance, building maintenance, steam pipe management, chilled water production, etc.). Prof-U, on the other hand, was much better at implementing cheap simple technologies or those which involved users. These included putting controllers on fume-hoods, dealing with users, limiting times and temperatures, simple retrofits, and so forth.[9]

EXPLAINING THE DATA: ORGANIZATIONAL LEVEL LOCAL RATIONALITY

Given that these organizations are identical in every other respect, I concluded that differences in structure and events in the institutional environment could explain almost all differences in decision making (i.e. decisions with virtually no lag, and the nature of the events which interrupted the long lags).[10] Allocation of responsibilities, which reflected prior choices of centralized versus decentralized structures, dramatically affected the universities' decision making capacities. The organization acted as a set of filters which sieved the set of feasible (in an engineering and economic sense) options (and problem definitions which led to feasible options) to a much smaller sub-set from which it selected. As a result, the sub-units exhibit what Cyert and March (6) termed local rationality (i.e. consideration of a reduced sub-set of options because of organizational level constraints). The institutional environment, at key junctures, facilitated decisions by providing inputs which compensated for the organizations' deficiencies. However, I extend Cyert and March's argument to suggest that for problems accorded low priority, as is often the case for energy conservation and waste reduction, the filter is very systematic and has a very fine mesh. To understand why that should be, it is essential to consider what it takes to make a decision.

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[9] See (5) for an extensive presentation of the data.

[10] The finding was supported by the other two cases in the study.

INFORMATION ACQUISITION AND ANALYSIS:

Every decision requires the bringing together of three distinct classes of information; technical information, contextual information, and connected information. Technical information is the most obvious. It generally comes from outside the organization, with potential solutions. Decentralization reduces an organization's ability to collect and analyze technical information in three ways.[11] First, decentralized organizations must reproduce their decision making apparatus for each sub-unit (e.g. faculty), making the gathering of technical information inefficient. Second, decentralization reduces the skills each sub-unit can aggregate, making information gathering incompetent. We see this played out in the technical capacities of the universities. Tech-U had 13 facilities engineers, Prof-U had two for the B.M.D. and faculties on the campus. Third, decentralization is not the norm for universities and so external vendors often cannot identify key people to approach at Prof-U (see (7)). For example, the smaller faculties at Prof-U stood to benefit enormously from the utility-sponsored retrofit program Tech-U used to replace its lighting. However, the utility took a year to find them (i.e. until after the program was initially scheduled to finish). Similarly, only one faculty at Prof-U installed compact fluorescent lights. Possibly, the vendor assumed that because one unit in the organization had purchased the technology, all had considered it.

Given its low information acquisition capacity, it should be no surprise that the B.M.D. at Prof-U did not even know about D.D.C. technology until the faculties purchased small systems in 1984, eight years after it came to market. Further, some lag-ending key decisions in the faculties at Prof-U were precipitated by exogenous inputs of technical skills and information. Most important, the move to scheduling the computer system, the five-year 50% reduction in energy consumption, and the purchase of micro-computer based controllers in the S.A.S can all be traced to a lunch a professor with an expertise and interest in energy conservation had with the dean in 1979. Prior to that, the faculty's energy conservation attempts had been disastrous. Similarly, the S.P.S.'s decision to schedule energy use was precipitated by its entering into a shared savings contract for one of its buildings.[12]

Technical information, however, is insufficient. Every energy conservation and waste reduction solution is implemented in a real location which carries contextual information about the space, its use, the intricacies of people's work lives and the idiosyncrasies of the equipment. To implement effective solutions, the specialist manager needs this contextual information. Decentralization increases a specialist manager's access to contextual information within the unit and decreases it across organizational partitions. We expect the manager to have much more information about the spaces and people with whom she deals regularly. Therefore, the energy managers at Prof-U are likely to know more about what is going on in academic domains than their counterparts at Tech-U, and the energy managers at Tech-U are likely to know more about what is going on in the university's infrastructure than those at Prof-U. This is reflected in the solutions. For example, when Tech-U finally installed compact fluorescent light bulbs, many were installed in irappropriate locations and manners. The nature of the program under which they were installed made poor solutions more politically acceptable, and therefore reduced the need for contextual information. Similar conclusions can be drawn for computer control scheduling and motion sensor installation.

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[11] Excludes very large organizations (which have different constraints).

[12] In a shared savings contract, an external party manages an aspect of an organization's operations in return for some the savings it realizes.

Finally, a host of people connected institutionally or geographically to the site of projects (e.g. allocators of resources, safety professionals) carry important information. With decentralization, we expect organizations to have more trouble implementing solutions which span between units. The fact that the first two generations of computer control spanned the faculties at Prof-U diminished implementation incentives (8).

RESOURCES, INCENTIVES AND POWER:

Every change in technology, no matter how simple, prevents alternative projects and changes the social relations between people, (e.g. (9)) and therefore potentially threatens everyone affected. For example, compact fluorescent light bulbs make 90% of bulb changers redundant. To implement any solution, unless the technology is very robust, the specialist manager must bring on-side every person who can possibly obstruct implementation, either aligning a project with their interest (e.g. through incentives or simplifying their job task) or through coercion. This includes workers, users, suppliers of resources, and other people in the organization (e.g. the safety office).

Decentralization, by definition, increases people's incentives to manage an objective. Similarly, if responsible groups are small, people are less likely to behave selfishly. This is why the facilities office in the S.A.S. set up a shared savings program of sorts with the individual buildings after the formal energy conservation program finished. The net result of relative decentralization on resource allocation at the two sites bears mentioning. Despite their apparently identical capital allocation criteria, at Tech-U, it is easier for people to raise $1 000 000 than $50 000. Large capital decisions are made by senior management. Capital beyond annual allocations needs to be large to attract attention. Hence, the event which enabled it to install compact fluorescent bulbs was a utility program which let it package $10.00 bulbs in multi-million dollar contracts. Prof-U facilities managers, in contrast, have reasonably easy access to capital within their faculty's

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[13] Once the control systems are in place, a lot of contextual information is needed to efficiently match the HVAC schedules to space usage.

jurisdiction. Beyond that, requests must go to the central university with the dean's support. This is problematic for the smaller and poorer faculties. Hence, the micro-computer based direct digital control systems, which are less than the $50 000 cut-off, are easy to acquire. A large direct digital control system, in contrast, would have required extensive negotiation between the B.M.D. and the faculties

Finally, let us briefly consider power; making people do what you wish. Decentralization increases the specialist manager's power relative to people in the same sub-unit. Hence, at Tech-U the energy managers have low power over users, which is reflected in the dearth of successful projects within academic spaces. Projects whose costs are borne by maintenance workers, however, are common. In contrast, at Prof-U the faculties traditionally had little power over the B.M.D. In order to achieve its 50% energy use reduction, the S.A.S. had to force a renegotiation of the contract joining it to the B.M.D., and increased its power considerably.[14]

DISCUSSION

I have argued, from rational choice assumptions, that organizations' structures dramatically constrain their decision making. If we consider their information acquisition and analysis ability and their power distributions and compare them to the information and power requirements of a given solution, then organizations will be unable to select solutions for which they have insufficient capacity.[15] End-of-pipe solutions are generally very accessible because they need large amounts of technical information but small amounts of contextual information and power. These requirements parallel the capacity of many environmental departments. Events outside the organization can change the balance of attributes and therefore make more solutions accessible.

If we assume that this argument extends beyond universities, we must conclude that organizational models offer much better predictions of waste reduction behavior than their economic counterparts. Institutional constraints, derived principally from the organization's structure and the institutional environment, almost invariably render market forces insignificant. The policy conclusion I draw from this is that ensuring that firms have a marginal incentive to reduce waste is a necessary, but grossly insufficient, condition for effective waste reduction.

Effective policies can do three things. First, they can change waste reduction technologies to be less dependent on power and the three types of information. For example, improved valves, control systems, etc. have this characteristic. Second, policies can change the external environment of the organization to make up for deficiencies within the organization. For example, technical assistance programs compensate for skills deficits. Subsidy programs overcome internal constraints caused by resource allocation procedures and increase managers' power. Citizen suits often force environmental and production managers into a dialogue and bring different types of information together. Finally, policies can aim to bring about permanent changes in the management of the organization to eliminate permanently some of the institutional barriers. Such policies might aim to persuade top management to treat environment as more important, encourage small waste reduction projects, innovation, and so forth. For example, an organization which raises waste reduction's importance is likely to increase the power of the waste manager, and hence improve her access to resources and technical information. Simultaneously, responsibility is likely to move further into line management, increasing the flow of contextual information. In this last domain, there is a possibility for a strategic link between EPA, OSHA, and the Commerce Department, since the organizational characteristics which lead to high quality in manufacturing are very similar to those which lead to safe and clean production processes.

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[14] A subsequent, detailed examination of waste reduction at a major chemical manufacturer (Dow Chemical) supports the findings.

[15] This neglects risk taking - selection of solutions outside the bounds.

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AN APPROACH TO HAZARDOUS WASTE REDUCTION AND POLLUTION CONTROL IN THAILAND'S UPCOMING TERPHTHALIC ACID INDUSTRY

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ABSTRACT

One of the major petrochemical industries that are currently being established at Map Ta Phut industrial complex on Thailand's eastern seaboard is a large Purified Terephthalic Acid (PTA) plant. Terephthalic acid is the key intermediate in the manufacture of polyester fibers and films, and is produced by the oxidation of para-xylene in acetic acid medium in the presence of a suitable catalyst in an autoclave. The anticipated undesirable side-products of oxidation of commercial para-xylene proposed to be used by the plant in Thailand, as they are in most such plants elsewhere, are isophthalic acid, mellitic acid, trimellitic anhydride, para-toluic acid, para-toluic ester and other straight-chain organic chemicals which would represent the principal hazardous pollutants in the plant wastewaters. Commercial para-xylene always contains certain amounts of ortho- and meta-xylenes as impurities; and isophthalic acid, mellitic acid and trimellitic anhydride which are produced solely from the oxidation of meta-xylene, constitute the bulk of the hazardous pollutants present in the wastewaters of a PTA or dimethyl terephthalate (DMT) plant. Almost all the aromatics and methanol released from a PTA or DMT plant are toxic in nature, but are biodegradable, however. Hence the wastewaters from such plants exert a very high oxygen demand with COD of the order of 6,000 mg/l and BOD of 750-2,000 mg/l.

On a request from the Government of Thailand, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) recently prepared technical guidelines for the mitigation of pollution of coastal waters of Southeast Asia from hazardous industrial wastes from a number of petrochemical and non-ferrous industries including PTA-DMT plants. In the guidelines prepared for PTA-DMT plants, the two important recommendations that have been made are: (i) exploring the use of pure para-xylene as the raw material so as to prevent or reduce significantly the generation of most of the hazardous pollutants, and (ii) installation of a two-stage activated sludge plant with its first stage unit having complete-mixed and the second stage unit with plug-flow hydraulic configurations and featuring extended aeration system for effective treatment of the wastewaters. These proposed measures are discussed in this paper.

INTRODUCTION

One of the major petrochemical industries that are currently being established at the Map Ta Phut industrial complex on the eastern seaboard of Thailand is a purified terephthalic acid (PTA) plant of Thai PTA Company Limited, a subsidiary of Imperial Chemical Industries (ICI) Ltd of U.K. Two polyester making plants are also being established as the PTA plant's downstream units. Although PTA is now used as the key intermediate for the manufacture of polyester fibers and films and has largely replaced dimethyl terephthalate (DMT) which was used earlier, many DMT plants are still operating in some countries in Asia.

Of all the petrochemical industries, PTA or DMT industry probably generates the strongest wastewaters containing a large variety of pollutants, many of which are also hazardous in nature. In view of this, the treatment of wastewaters from this industry is usually carried out jointly with other petrochemical industry wastewaters in a common facility as far as practicable. But in some countries as in Thailand, individual ownerships of such industries may often compel them to install and operate their own waste treatment plants. Treatment of such hazardous wastes at individual plant level often requires the application of advanced technology. Therefore, on a request from the Government of Thailand, the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) recently prepared pollution control guidelines for a number of petrochemical and non-ferrous industries including the PTA industry presently being established at Thailand's eastern seaboard. The findings and recommendations contained in the guidelines on PTA-DMT industry (1), which are summarized in this report, also include the strategy for minimizing waste generation in this industry.

MANUFACTURING PROCESS

To facilitate an understanding of the sources and types of pollutants generated in a PTA industry, the ICI Pure Terephthalic Acid Process (Figure 1) which has been proposed for the plant in Thailand, is briefly described here. This process involves oxidation of para-xylene (p-xylene), $C6H4(CH3)2$, with air in the presence of acetic acid and a suitable catalyst (such as cobult, manganese, or bromine) and at a controlled temperature and pressure when terephthalic acid (TA), $C6H4(COOH)2$, is produced. TA, being insoluble in acetic acid, crystallizes and is separated from the acid by filtration. It is then dried to give crude TA. A part of the acetic solvent, including catalyst, is recirculated to the reactor. The remaining acetic acid is concentrated by evaporation before recycle to the oxidation reactor. The organic residues are disposed of by incineration.

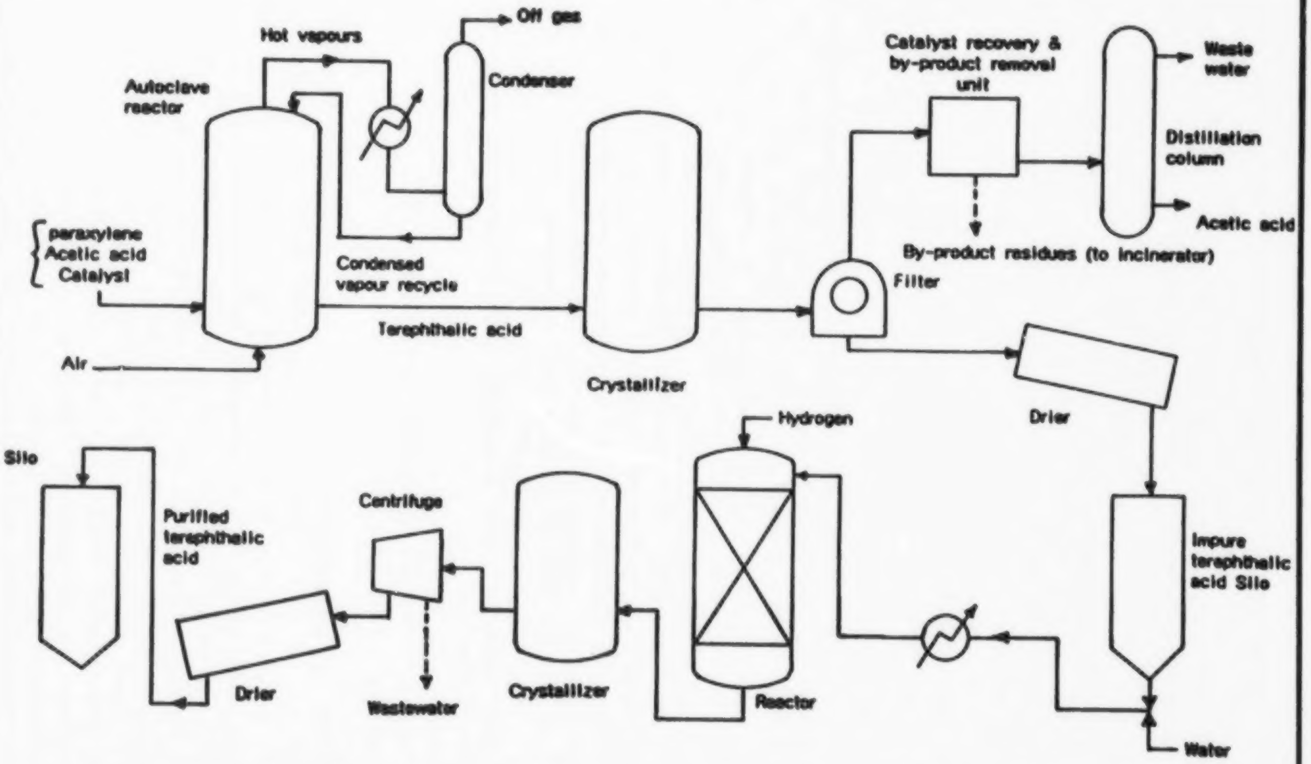

Figure 1. Simplified Flow Diagram for the Manufacture of Purified Terephthalic Acid

p-xylene used in a PTA plant usually contains certain amounts of ortho- and meta-xylenes as impurities which also participate in the oxidation reaction to produce side-products such as phthalic acid (ortho-acid) and isophthalic acid (meta-acid). In the quantities produced, none of these chemicals can be recovered economically, so they are extracted as a molten residue and incinerated. Also, due to partial oxidation of p-xylene, 4-carboxybenzaldehyde (4-CBA), $C_6H_4CHOCOOH$, and other by-products like benzoic acid, $C_6H_5.COOH$, and trimellitic acid, $C_6H_3(COOH)_3$, are formed. These by-product acids are largely removed as molten residue during the soild-liquid separation stage and incinerated. 4-CBA remains as an impurity in the crude TA crystals which are purified by dissolution in hot water followed by selective catalytic hydrogenation when the 4-CBA is converted to para-toluic acid, $C_6H_4.CH_3.COOH$. Purified terephthalic acid (PTA) is then crystallized from the aqueous phase, centrifuged and dried for its direct esterification with ethylene glycol to produce polyethylene terephthalate in a polyester plant.

SOURCES AND CHARACTERISTICS OF WASTEWATERS

p-toluic acid produced from 4-CBA, and other organics including isophthalic and trimellitic acids (or anhydride), acetic acid, methyl acetate, methyl alcohol, formic acid, formaldehyde and also a small amount of unrecoverable TA are purged from different process units. The concentrations of the abovementioned chemicals in the process effluents are appreciable. It is reported (2) that the process wastewaters of a DMT plant in India, which constituted less than 4 per cent of the daily volumes of flow of the plant wastewaters (including cooling tower blowdown), accounted for over 95 per cent of the total BOD. Table I shows the composition of this undiluted effluent stream. BOD values of the wastewaters varied from 750 mg/l to 2,000 mg/l.

TABLE I. COMPOSITION OF PROCESS WASTEWATERS FROM A DMT PLANT

Compounds	Concentration in process wastewaters (% w/w)	Conc. in composite wastewaters, mg/l
Acetic acid	2.4	935
Formic acid	1.3	506
Formaldehyde	0.26	97.5
p-toluic ester and methyl benzoate	0.27	101
Soluble organics including methanol	1.5	700

Lau (3) reported that the normal concentrations of different organic components present in the process wastewaters of TA plants in the United States are as shown in Table II. Typical COD of the process wastewaters was 6,000 mg/l. The strength of process wastewaters from a TA/PTA plant varies widely from plant to plant, depending upon the purity of p-xylene used, the process operated, the extent of recovery and recycle of by-products and the water usage in the plant. Some operating plants in India, U.K. and U.S.A., have reported BOD values of their wastewaters ranging from 2,000 mg/l (2) to 3,650 mg/l (4) and the COD values around 6,000 mg/l (3), while a new plant proposed to be established in the Republic of Korea has estimated the BOD and COD of its potential wastewaters to be about 8,000 mg/l and 9,800 mg/l, respectively (5).

TABLE II. TYPICAL COMPOSITION OF PROCESS EFFLUENTS OF A PTA PLANT

Components	Concentration, mg/l
Terephthalic acid	600
Isophthalic acid	600
Trimellitic anhydride	600
Acetic acid	2000

CURRENTLY PRACTICED POLLUTION ABATEMENT TECHNOLOGIES

A few case studies are briefly described here to illustrate the successes and constraints of treatment of DMT- and PTA plant wastewaters.

CASE STUDY I

Possibly the first extensive study on the treatment of high BOD wastewaters of a DMT plant in multi-stage bioreactors was carried out by Chakrabarty (2) at the Indian Petrochemicals Corporation Ltd (IPCL) at Baroda, India, in 1973. The plant included a neutralization tank, a two-stage oxidation ditch (the first stage having a volume of 880 cu.m and the second stage of 2,250 cu.m) with nutrient dosing arrangement, a final clarifier with sludge recirculation system and a sludge dewatering bed (Figure 2). The plant was operated with wastewater flows varying from 1,020 cu.m/day to 2,340 cu.m/day and having BOD values ranging from 750 mg/l to 2,000 mg/l and at an MLVSS concentration of 1,968 mg/l to 3,050 mg/l. The first-stage aeration tank was operated at an overall F/M of 0.874 kg BOD/kg MLVSS-day and the second stage at 0.092 kg BOD/kg MLVSS-day. A summary of the results of performance of this plant is shown in Table III. The average BOD reduction in this plant was greater than 99 per cent.

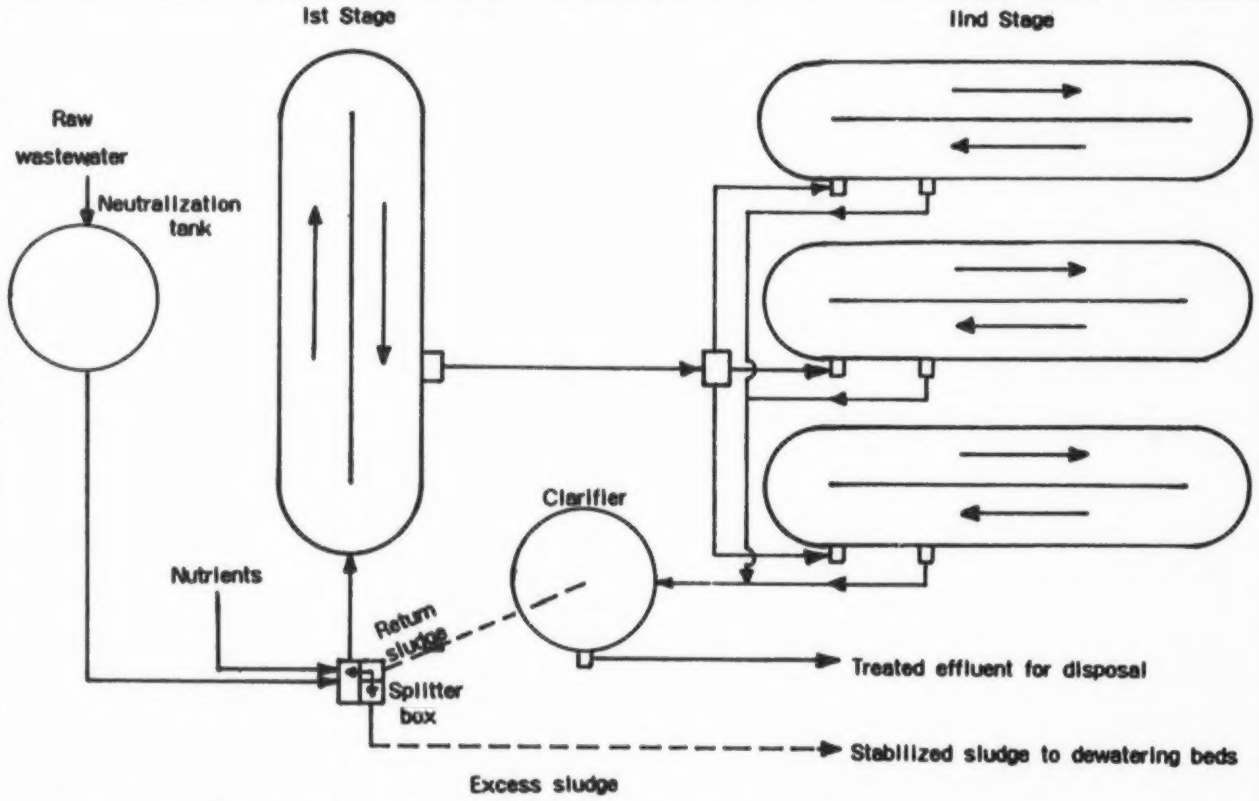

Figure 2. Flow Diagram for Treatment of DMT Wastewaters in Two-Stage Oxidation Ditches

TABLE III. SUMMARY OF THE RESULTS OF PERFORMANCE OF TWO-STAGE OXIDATION DITCH TREATING DMT WASTEWATERS

		FIRST STAGE				SECOND STAGE			
Date (1973)	Flow m3/d	Det. time hr.	MLVSS mg/l	Inf. BOD mg/l	Eff. BOD mg/l	Det. time hr.	MLVSS mg/l	Inf. BOD mg/l	Eff. BOD mg/l
July									
26	1,165	18.0	2,400	1,400	155	26.5	2,460	155	10.5
27	1,960	10.8	2,300	750	145	15.8	2,345	145	2
28	1,630	13.0	2,180	1,200	115	18.9	2,248	115	5
30	1,280	16.5	2,140	1,000	115	24.0	2,200	115	4.5
31	2,340	9.0	1,968	1,675	120	15.3	2,140	120	10
August									
2	1,500	14.0	2,650	2,000	180	20.6	2,720	180	11
3	1,470	14.4	3,050	1,200	-	21.6	3,040	-	8.5
8	1,790	11.8	2,875	900	125	18.7	2,880	125	12.8
11	1,870	11.3	2,460	850	110	18.1	2,470	110	14.4

CASE STUDY II

A similar study on bio-oxidation of TA plant wastewaters in multistage aeration tanks was performed by Lau (3) of Amoco Chemicals Corporation, Naperville, Illinois, U.S.A. The investigator used three bench-scale activated sludge units: a single-stage reactor, a two-tanks-in-series reactor, and a three-tanks-in-series reactor, each equipped with an external clarifier. A synthetic feed of the composition as shown in Table II was used. An MLSS concentration of 6,000 mg/l and an overall feed to microorganisms ratio (F/M) of 0.5 kg COD/kg MLSS-day were maintained in the bio-reactors. The results of operation of the three bench-scale units showed that under oxygen non-limiting conditions (100% air supply, above 3 mg/l DO in the first tank of the tanks-in-series unit), the average COD reduction was greater than 98 per cent in a three-tanks-in-series system and over 96 per cent in a two-tanks-in-series system. The effluent COD values of these two systems were at or below 100 mg/l and 175 mg/l, respectively.

CASE STUDY III

Terephthalic acid plant wastewaters have also been effectively treated by the Deep Shaft process developed by Imperial Chemical Industries (ICI) Ltd, U.K. Although this process has so far been used in more than 50 sewage and industrial waste treatment plants, mostly in Japan and U.K., there is presently one such installation at Wilton, U.K., where, since 1981 a TA plant has been treating its wastewaters by this process. The plant wastewaters (2,650 cu.m/day) having an average BOD of 3,650 mg/l are treated in a single-stage deep shaft to produce an effluent with an average BOD of 300 mg/l (4).

AN APPRAISAL OF THE CASE STUDIES

There appears to be a similarity of approaches and observations made in the Case Studies I and II, although in Case Study I, full-scale two-stage combined complete-mixed-plug-flow reactors (oxidation ditches) were used and in Case Study II, bench-scale two- and three-stage complete-mixed reactors (CFSTR) were used. By using a multi-stage configuration of the reactors, both the investigators obtained 98 to 99 per cent BOD reduction. In contrast, a single-stage unit used in Case Study III could achieve a BOD reduction of a little more than 90 per cent. These observations indicate that a single-stage reactor, even featuring an extended aeration system, would be incapable of producing the low effluent BOD achievable in a multi-stage reactor.

SCOPE OF WASTE REDUCTION IN THE PTA INDUSTRY

Terephthalic acid industry is one of the petrochemical industries that has not yet been able to resolve the problem of generation of highly polluting wastes in spite of developing and using improved manufacturing technology for more than a decade now. The major steps that have been taken by this industry in achieving economy in its manufacturing processes, and at the same time in reducing the generation of wastes to a certain extent, is the abandonment of production of DMT as the second intermediate and of the use of nitric acid as a solvent for p-xylene in the oxidation reactor. This resulted in the elimination of methyl alcohol and a number of other toxic and hazardous pollutants associated with the manufacture of DMT. Even with this improvement, the magnitude of pollution potential of this industry has not diminished to any significant extent. This is because of the fact that the basic process of oxidation of p-xylene in acetic acid medium to manufacture terephthalic acid has remained practically unchanged in modern PTA plants. As a significant amount of the by-product chemicals (as pollutants) are generated in the p-xylene oxidation process itself, the PTA plants generate almost as strong a wastewater as do the DMT plants (Figure 3).

The organic pollutants that are generated in the PTA industry are primarily the oxidation products of o-xylene and m-xylene which remain as impurities in the feedstock (p-xylene) supplied to the industry by p-xylene producers. Although the oxidation of pure p-xylene is also likely to produce some amounts of benzoic and trimellitic acids as by-products, the quantum of these pollutants should be much less than that produced from the oxidation of impure p-xylene. Therefore, by using pure p-xylene as the feedstock, a number of currently practiced operations in the industry can be reduced, thereby bringing about further economy in the manufacturing process and also minimizing the costs of pollution control in this industry.

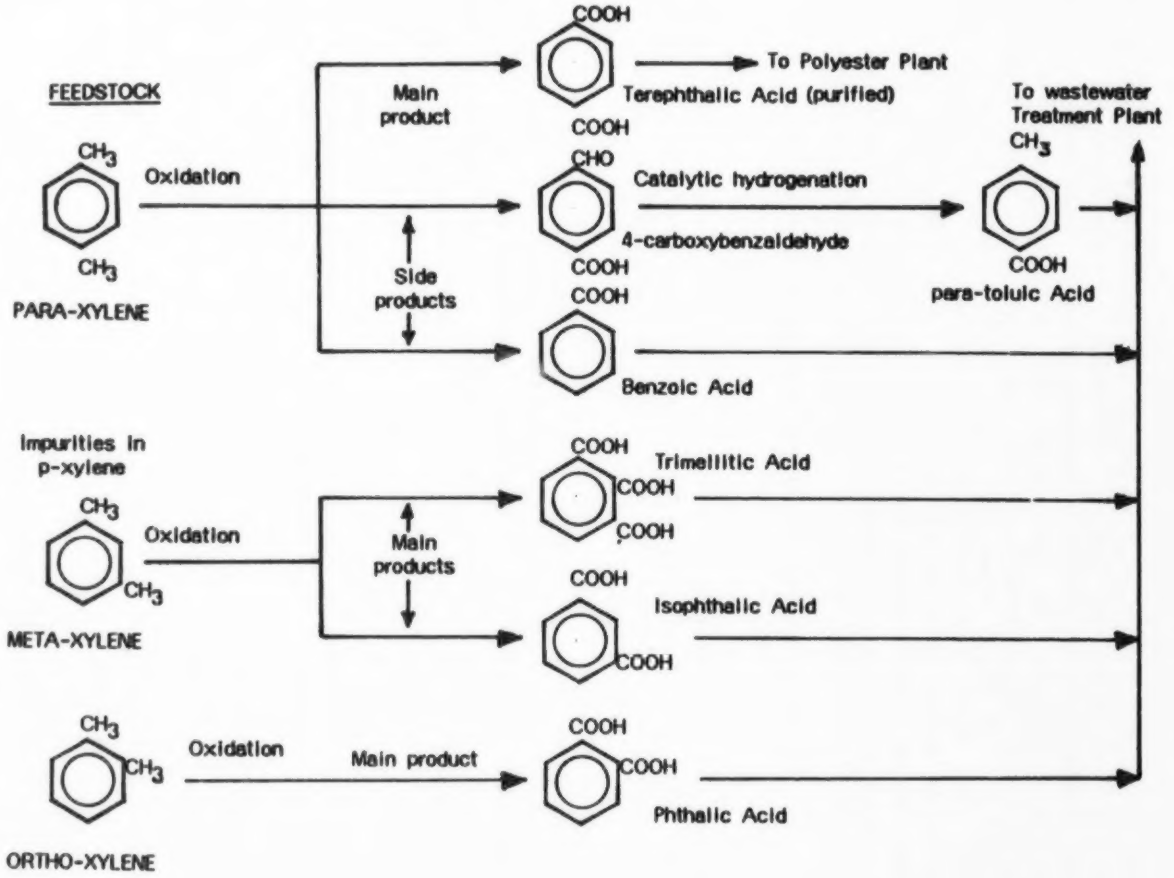

Figure 3. Major Pollutants Generated in the Oxidation of Commercial grade p-xylene in PTA Plants

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ADDRESS BEFORE THE EPA/IACT INTERNATIONAL CONFERENCE ON POLLUTION PREVENTION

by: Dr. Barry Commoner
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This conference comes at a crucial moment in the history of environmentalism. Two months ago, millions of people in dozens of countries bore witness to the elevation of the environmental crisis to the top of the global agenda. Even more than the first Earth Day 20 years earlier, Earth Day 1990 confirmed the nearly universal commitment to restoring the quality of the environment.

But the two Earth Days differ sharply in their results. In 1970, Earth Day was the signal for action: a series of far-reaching environmental laws were passed; the U.S. Environmental Protection Agency (EPA) and state environmental agencies were established; local clean-up campaigns were organized; schools adopted new environmental courses. In 1990, Earth Day has come -- and gone -- leaving scarcely a trace in the country's life. No new remedial programs have been proposed; the Congress is still debating a Clean Air Bill that -- failing to recognize what we have learned over the last 20 years -- was obsolete on the day it was written; a curious silence has descended on the airwaves and editorial pages.

The chief message about how to clean up the environment that emerged from the recent festivities is: do it yourself. Some examples, gleaned from one of the numerous published lists: "live within walking distance of your job; carry your own shopping bag; keep the lint screen in the clothes dryer clean; be creative with leftovers; go barefoot." Virtuous as they are, these measures are hardly adequate to a world confronted with the massive task of preventing global warming and ozone depletion, of eliminating smog and acid rain, of sharply reducing exposure to toxic chemicals.

I have been particularly concerned about this discrepancy because early on I called for a new understanding of the environmental crisis: to explain why, despite the huge and costly effort, the environmental problem persists; to prevent pollution instead of trying to control it; and to achieve that through a massive, world-wide transformation of our systems of agriculture, manufacturing, energy production, and transportation.

This urgent message, I regretfully report, was lost in the glamorous din of the recent Earth Day. In the quiet aftermath we are obliged, I believe, to speak out and, as clearly and as forcefully as we can, awaken the world, not simply to the size and urgency of the problem -- that is well known -- but to the monumental scope and radical impact of the necessary remedy. We need to fill the vacuum left by the trivialization of Earth Day and -- as I shall show -- by the failure of this Administration to provide leadership in the new, more meaningful direction.

To appreciate the sweeping significance of pollution prevention as the guiding strategy for resolving the environmental crisis, we need to go back 20 years, to the law that defined U.S. environmental policy -- the National Environmental Policy Act (NEPA). The stated purpose of that Act is:

> "To declare a national policy which will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man." [emphasis added]

What is most significant about this clear-cut statement of U.S. environmental policy is that for 20 years it was ignored. The simplest evidence is that 20 years after NEPA, in the Federal Register of January 19, 1989, EPA found it necessary to announce pollution prevention -- as a new policy. In the Pollution Prevention Policy Statement signed by the former Administrator, Lee M. Thomas on that date, the novelty of this position is made quite clear. The statement acknowledges that EPA's past effort "had been on pollution control rather than pollution prevention" and asserts that "...today's notice commits EPA to a preventive program to reduce or eliminate the generation of potentially harmful pollutants."

I have emphasized the word "generation," because it sharply distinguishes the new policy from the old one. The earlier, control strategy accepts the existence of the facilities that generate the pollutants -- the automobile or the power plant -- and then prescribes appended control devices -- catalytic converters or scrubbers -- to trap the pollutants before they can enter the environment. Prevention, instead, calls for replacing the present facilities themselves with new kinds of cars and power plants that do not generate the pollution, obviating the need for a control device.

In the 20-year period between NEPA's pronouncement that pollution prevention is national policy and its adoption by EPA, the United States has made a massive effort to restore the quality of the environment. More the $1 trillion of public and private money has been spent to control rather than prevent pollution; impressive bureaucracies have been created; numerous regulations have been enacted. But with what results? Mr. Thomas' policy statement answers this question diplomatically: "...EPA realizes that there are limits as to how much environmental improvement can be achieved under these [i.e., control] programs." I can be less diplomatic, and assert as I did in an earlier address to the EPA staff (in January 1988) that "...the massive effort that began in 1970 has failed to restore the quality of the environment."

At that time, and more recently in my book, Making Peace with the Planet, I reviewed the available numerical data regarding emissions and environmental concentrations of pollutants that lead to this conclusion. it is useful to summarize these data here, for they show not only that the controls strategy has failed, but more important, that -- in the very few instances in which, more or less by accident, it has been applied -- the prevention strategy has succeeded.

The data show that, with very few exceptions, the effort to reduce the emissions and environmental concentrations of pollutants has failed. Improvement in annual emissions of the standard air pollutants -- particulates, sulfur dioxide, carbon monoxide, nitrogen oxides, and volatile organic compounds -- has been modest at best. Between 1975, when the acquisition of uniform annual data began, and 1987, the average reduction in these emissions was only 18%, including a 2% increase in nitrogen oxide emissions. Similarly, a U.S. Geological Survey study of the levels of standard water quality factors -- fecal coliform bacteria, dissolved oxygen, nitrate, phosphate, and suspended sediment -- at several hundred river sites throughout the country shows that between 1975 and 1983 the average levels improved at 13.2% of the sites; they deteriorated at 14.7%; and remained unchanged at 72.1%.

Qualitative improvement of the order envisaged in the environmental legislation of the 19703 -- 70% to 90% -- has occurred only in the case of a handful of pollutants: airborne lead emissions, which have declined by 94% between 1975 and 1987; DDT and PCB concentrations, which have declined in human body fat by 70-80% in the decade following 1970; mercury concentrations in Great Lakes sediments, down by 80% between 1970 and 1979; strontium 90 concentrations in milk, which have declined by 92% between 1964-1984; and, in a few local sites such as the Detroit River, a 70% reduction in phosphate concentrations between 1971 and 1981. The numerous failures and the rare successes tell the same story: pollution prevention works; control devices do not. Environmental pollution is an incurable disease; it can only be prevented.

Every pollutant on this very short list of successes reflects the same remedial action: production of the pollutant has been prevented. Lead has been almost entirely removed from gasoline; DDT and PCB have been banned; mercury has been removed from chloralkali production; where phosphate has been eliminated from detergents, concentrations in surface waters have declined; the atmospheric nuclear bomb tests that produced strontium 90 have been halted.

In each case the production process that originally generated the pollutant has been changed. In gasoline production, lead has been replaced by organic octane boosters; in cotton production, DDT has been replaced by other insecticides; in transformer production, PCBs have been replaced by other dielectric fluids; in chloralkali plants, semipermeable membranes are now used in the electrolytic cells instead of mercury. In sum, the strategy of pollution prevention requires an appropriate change in the technology of production; the change entirely eliminates the pollutant, reducing emissions to zero. In contrast, the strategy of control attempts only to reduce the amount emitted -- and fails to do so appreciably.

One of the rules of environmentalism is "There is no free lunch," a reminder that there is a cost associated with every environmental mistake. The mistaken strategy of control is no exception. it has not only rendered futile the huge 20-year effort to clean up the environment, but has also created new problems that could have been avoided had the strategy of pollution been implemented instead of being entombed in NEPA.

A major consequence of the effort to combat pollution by applying control devices to the otherwise unchanged facilities that generate it is the much-lamented -- but spurious -- conflict between environmental quality and economic development. This conflict has led to the claim that since economic development depends on increased use of the same technologies that generate pollutants -- modern automobiles and trucks, fossil fuel and nuclear power plants, or chemical agriculture -- then it follows that environmental quality demands limits on economic growth. This claim has a chilling effect on communities and countries that are struggling to overcome the most serious assault on the quality of life -- poverty.

Experience with the strategy of control appears to confirm the reality of this conflict. Thus, one reason why emissions from motor vehicles and power plants have decreased only slightly since 1975 is that vehicular fuel consumption has increased by 11.3% and electric power production by 9.8% in that period of time. Since they are never perfect, the increment in overall activity counteracts the modest reduction in emissions that the control devices can achieve. On the other hand, when a preventive measure is employed -- for example, removing lead from gasoline -- emissions are reduced to zero regardless of the level of activity. After all, any number multiplied by zero remains zero.

Thus, if we rely on control devices that only partially reduce emissions, then increased activity will counteract their effect -- and there is, indeed, a conflict between environmental quality and economic development. Nor can this conflict be relieved by raising the efficiency of the control device to 100%, for this inevitably involves exponential increases in their costs -- adding to the cost of production and, again, generating a conflict between environmental quality and the economy.

In fact, changes in production technology motivated by pollution prevention will often themselves improve economic productivity. For example, in the United States, the economic productivity of agricultural chemicals -- i.e., the dollar return on the investment in them -- has decreased by some 70% since they were introduced in 1950. There is now a good deal of evidence that the prevention-motivated alternative -- organic agriculture -- is economically successful compared with conventional agriculture. Similarly, with the cost of producing fossil fuels inevitably escalating as supplies are depleted, solar alternatives that are renewable and therefore stable in cost become economically advantageous. Indeed, it is safe to say that if American industry would gear up to produce smogless cars and trucks, low-cost sources of solar energy, and processes that sharply reduce the environmental burden of toxic chemicals, it could recover a good deal of the vitality that it has lost to other, more innovative, national economies.

This conference testifies to the fact that the principles of pollution prevention have been widely appreciated and are beginning to be applied. Efforts are being made to reduce the amounts and toxicity of the wastes that are generated, and where possible to recycle them. Pollution prevention is beginning to move from policy to practice.

But there are serious obstacles which, unless they are confronted and resolved, will, I believe, hold back the full-scale development of the strategy of prevention and -- once again -- frustrate our effort to restore the quality of the environment. In order to identify these obstacles and come to grips with the task of overcoming them, we need to look at some of the larger implications of implementing the strategy of prevention. For this purpose it is useful to examine a specific -- and large-scale -- source of environmental pollution: the automobile.

In the 1970s the automobile was recognized as the source of at least several major environmental pollutants: carbon monoxide, photochemical smog, and lead. Guided by the strategy of control, EPA tackled the problem by prescribing a control system to reduce emissions of carbon monoxide and nitrogen oxides. In a detailed rule-making document, EPA prescribed specified control devices and predicted that they would reduce national carbon monoxide emissions by 80% and nitrogen oxide emissions by 70% between 1975 and 1985. This prediction turned out to be far off the mark; in fact, carbon monoxide emissions declined by only 19%, and nitrogen oxide emissions increased by 2% in that period. And since nitrogen oxides trigger smog production and contribute significantly to acid rain, there has been little improvement in these important environmental problems.

The original estimates took into account the several relevant factors, including the efficiency of the control system (chiefly the catalytic converter) and the expected increase in traffic. The failure to achieve the predicted reductions revealed that the efficiency of the control system was insufficient to overcome the approximately 11% increase in automotive fuel consumption over that period. Meanwhile, it was discovered that lead, then widely used in gasoline as an octane-booster, poisoned the catalytic converter's platinum catalyst, and EPA moved to rapidly eliminate lead from gasoline production. As a result, national lead emissions (from all sources) has declined by 94% since 1975. This is one of the few real environmental successes; it has reduced the toxic effects of lead emissions, for example in inner-city children where it had been sufficient to account for symptoms of mental retardation.

The sharp reduction in lead emissions shows that pollution prevention works; the failure to significantly reduce carbon monoxide and nitrogen oxide emissions shows that the control strategy does not.

How could the principles of pollution prevention be applied to carbon monoxide and nitrogen oxides? The basic principle is clear from the example of lead: change the technology of production so as to eliminate the pollutant at its point of origin. The generation of both carbon monoxide and nitrogen oxides is inherent in the operation of the automobile engine -- in one case, because of incomplete combustion, and in the other because of the elevated temperature of high-compression engines. The principle, then, is to change the engine so as to eliminate its propensity for producing these pollutants. The generation of nitrogen oxides can be eliminated by reducing the engine's compression ratio or by redesigning it to localize the high temperature (as is done in the stratified charge engine.) But carbon monoxide production can be eliminated only by doing away with the internal combustion engine itself, for example by using an electric motor instead.

For the sake of this example, let us agree that both carbon monoxide emissions and the generation of nitrogen oxides and the resultant photochemical smog should be eliminated by replacing the present automobiles with electrically driven ones. The first fact to take note of is that this clean automotive technology exists. It was widely used in the 1920s when, as I recall, the trucks operated by the Railway Express Company (the predecessor of American Express) in New York City were driven by electric battery-powered motors. Indeed, General Motors has recently exhibited a prototype electric car that they state will be produced for sale at some unspecified date. Thus, there is at present no technological barrier to replacing the present cars, at least in urban areas, with electric ones, thereby eliminating most urban air pollution -- a notorious, unsolved environmental problem.

Why, then, has this urgently needed example of pollution prevention not been adopted? There are, of course, numerous obstacles to this much-to-be-desired eventuality. The most important one is that General Motors is understandably reluctant to invest in the necessary new production facilities until a sufficiently large demand for the car is established. Unlike conventional cars, there is at present no existing market for electric cars. And so we are frozen into inaction.

Yet there is a way to break out of this paralysis and begin the large-scale introduction of electric cars, at least in urban areas. The federal government buys about $7 billion of cars and trucks annually, many of which could be suitably replaced by electric vehicles. Many such vehicles are also purchased by state and city governments. Taxis, which make up a considerable part of the traffic in cities like New York, although privately owned, are subject to municipal regulations regarding their design. Surely this represents a demand for electric cars sufficient to enable General Motors to invest in producing them -- creating at once a market that will facilitate private purchases as well. In sum, federal and other government orders for the purchase of electric cars -- or, for highway travel, cars with stratified charge engines -- is a practical way of generating the transformation in transportation technology that is the only effective means of lifting the heavy burden of vehicular air pollution.

What can be done in the area of electric power production -- another major, persistent source of environmental pollution? The environmental consequences of our present technologies are well known: power plants that burn coal, oil or natural gas afflict the environment with emissions of sulfur dioxide, nitrogen oxides, dust, and a noxious mixture of organic compounds. They generate a great deal of carbon dioxide that contributes to global warming. Nuclear power plants eliminate the carbon dioxide problem -- but only through a Faustian exchange with the intractable problems of radioactive contamination.

Pollution prevention calls for a transformation in the technology of power production. It leads us, for example, to a source of electricity that generates neither carbon dioxide, noxious air pollutants, nor radioactivity--photovoltaic cells. What stands in the way of adopting this ecologically sound, clean technology is its price. Photovoltaic cells and their auxiliary equipment, such as batteries, are still too costly to compete in the major market for utility electricity. Photovoltaic cell production is already well developed, and the small industry that now exists, chiefly in the United States and Japan, is reliably supplying photovoltaic cells for portable electronic appliances and remote installations -- applications that do not compete with electric utilities.

Yet there is little motion toward large-scale application of photovoltaic cells as a means of reducing the severe environmental impact of the present, massive production of power from fossil fuels and nuclear reactors. Sharp price reductions could be achieved, and the market increased, by greatly expanding production facilities, with the resultant economies of scale. But at the present price, the demand is small and insufficient to justify the investments needed to expand production.

Here, too, a government procurement program would solve the problem. This is not a new idea. Just such a program was proposed during the Carter Administration, in the form of a bill -- passed by Congress but vetoed by Mr. Carter -- for a $400 million purchase of photovoltaic cells for use in federal installations. (This proposal was based on earlier experience with the impact of large-scale federal procurement of integrated circuit computer chips in the 1950s -- which sharply expanded production and reduced their price by some 95% over a five-year period and thereby created the present computer industry.) It was estimated that a procurement program representing 150 megawatts of power would reduce the then-current price of $20 per peak watt to $0.50 over a five-year period. As the price drops, the market for photovoltaic electricity expands enormously. At $1 per watt, photovoltaic cells become economically feasible for roadside lighting, representing a demand of about 50,000 megawatts. At $0.50 per peak watt, photovoltaic cells were expected to complete with utility power in many parts of the country. Once again, a federal procurement plan, which could readily be augmented by state and municipal purchases, would generate the demand needed to bring this pollution-preventing, environmentally clean production technology into the market.

Recycling is a major feature of pollution prevention, for by keeping materials in their separate, useful state, it prevents the generation of trash. A major obstacle to large-scale recycling, which, as a recent CBNS test has demonstrated, can dispose of as much as 84% of household trash, is the lack of markets. This difficulty in turn is largely due to the potential users' reluctance to make the necessary investments in process modifications. All this could change almost overnight if the federal (and other) governments would simply decide to buy only recycled paper.

How could the strategy of pollution prevention be applied to the pervasive environmental problems generated by the heavy use of synthetic pesticides and chemical nitrogen fertilizers in agriculture? To prevent the resultant environmental impact, which leads to pollution of groundwater and water supplies -- and, all too frequently, to food unacceptably contaminated with toxic pesticide residues -- the technology of agricultural production must be changed. The heavy application of chemical nitrogen fertilizer must give way to natural sources -- nitrogen-fixing plants and organic forms of soil nitrogen -- and pests must be controlled by their natural predators instead of by synthetic chemicals. We now know from a recent National Research Council/National Academy of Sciences report that this is both technically and economically feasible. This confirms a much earlier CBNS study that showed from a detailed comparison of a group of large-scale Midwestern farms with otherwise similar, conventional ones that organic farms produce only 8.5% less output but achieve exactly the same income per acre.

What stands in the way of transforming U.S. agriculture -- wholesale -- from its present chemically based technology to organic farming? In fact, this transformation is already under way, albeit slowly, for organically grown fruits and vegetables are now in the market, appearing regularly, for example, on the shelves of New York City supermarkets. However, organic food sells at a price premium of as much as 50%. This effectively limits the market to affluent people, separating the food supply into two streams, one free of chemical contamination but available only to the rich, and the other, often contaminated by pesticide residues, but available to the poor.

Apart from the untoward moral consequences of this situation, the small market for organic food prevents economies of scale and perpetuates the high prices that stand in the way of large-scale expansion. A major obstacle is that it may take five years or more after chemical agriculture is stopped for the natural fertility of the soil and the natural balance between pests and predators to be restored -- a period in which the farmer may need federal support. Again, these difficulties could be readily overcome by procuring organic produce for cafeterias and restaurants that serve federal establishments. Imagine the impact of a White House state dinner free of agricultural chemicals and a menu printed on recycled paper.

Thus, we are at a crucial point in the 20-year effort to clean up the environment. We have made a massive attempt to significantly reduce pollution levels with control devices -- and have failed. But we have learned what works: preventing pollution by transforming the production technology that generates the pollutant, to eliminate it. We also know that the necessary clean technologies are largely in hand. Yet this is the only workable way of responding to the insistent public demand for environmental action. We are confronted, therefore, by the intimidating prospect of a radical transformation of the national system of product -- in agriculture, transportation, energy, and manufacturing.

Nevertheless, I have demonstrated, I believe -- here, in an earlier account in the EPA Journal, and in more detail in my recent book, Making Peace with the Planet -- that there is a powerful tool, in the hands of federal and state governments and even some municipalities, that can break us out of this impasse: government procurement of the clean technologies.

That we are at a momentous, historic juncture has been recognized by William K. Reilly, the EPA Administrator, who recently said:

> "...The dawning of the third environmental decade finds us at a historic turning-point -- a time when we must find a new approach to meeting our needs...a new approach to managing waste: pollution prevention."

Moreover, in testimony to Congress, Mr. Reilly has cited the importance of using federal procurement programs to develop markets for recycled materials and other products of clean pollution prevention-guided technologies. Finally, principles of pollution prevention have been embraced by President Bush himself when, last June, in an address to a Washington environmental group, he declared himself not only an environmentalist but a preventionist as well. And, given the fortuitous timing of Earth Day 1990 -- when the whole world was engrossed with environmental concerns -- there was a marvelous opportunity for Mr. Bush to respond by taking the one step that would begin to put pollution prevention into action: government procurement.

I say all this to explain my enthusiastic reaction to the discovery, shortly before Earth Day, that the EPA had, in fact, moved to turn that event into a truly historic one. EPA had prepared, for Mr. Bush's approval, a Presidential Executive Order, to be announced on Earth Day, that would set in motion a comprehensive federal procurement program, soundly derived from the principles of pollution prevention. The objectives of the proposed order are worth quoting in full, for they reflect a deep understanding of the nature and significance of the new policy:

> WHEREAS, traditional environmental protection approaches which stress treatment and disposal after pollutants have been generated will not be adequate to assure protection of human health and the environment. Pollution prevention and recycling must become the focus of our long-term strategy for environmental protection, and
>
> WHEREAS, the Federal government can no longer view energy, transportation, agriculture, and natural resource policies as discrete from the Nation's long term environmental protection objectives. These policies must become instruments to achieve the protection of human health and the sustainable development of our resources in an ecologically safe manner, and
>
> WHEREAS, the Federal government should become a leader in the area of pollution prevention, recycling, and procurement. The Federal government should function as a proving ground for innovative pollution prevention programs and technologies, should build markets for clean products, and should incorporate pollution prevention into the basic daily choices of Federal employees, and
>
> WHEREAS, as the single largest consumer in the Nation, the Federal government has the opportunity and the responsibility to move into the forefront of pollution prevention and solid waste management by both reducing the amount of waste that the government produces in the first place, and by recycling as much of the remaining waste as possible.

The executive order calls on "...all Federal Agencies, and Government-owned, contractor operated facilities (GOCOs) [to] reduce the generation of pollutants and waste...and set an example for the rest of society through the development of pollution prevention, recycling, and procurement programs... [to] stimulate demand and markets for clean, recyclable and recycled materials by revising procurement policies and specifications."

Section 506(c) of the proposed Executive Order gives the EPA Administrator the authority to take actions that would put the Federal procurement program that I have outlined in place:

> "The Administrator of the Environmental Protection Agency shall...'provide guidance to assist procuring agencies in promoting the purchase of recycled products, clean technologies and products, and products that maximize energy or water efficiency and conservation.'"

Under these terms, "clean technologies and products" would include electric cars and organic foods, and "products that maximize energy or water efficiency and conservation" would include photovoltaic cells.

So, I am happy to report that under Mr. Reilly's leadership, EPA has devised a program that would put pollution prevention into practice -- an action that could have turned Earth Day 1990 into a truly historic event. Unhappily, I must also report that the proposed Executive Order was killed by the President's Domestic Policy Council.

That President Bush failed to seize this opportunity to endow Earth Day 1990 with the momentous content that it merited -- he went fishing instead -- can be traced, I believe, to his Chief of Staff, Mr. Sununu. In his powerful position, which includes a guiding role in the Domestic Policy Council, Mr. Sununu, often abetted by Richard Darman, Director of the Office of Management and Budget, has a record of environmental obstructionism. Mr. Sununu intervened to overrule EPA and seriously weaken the Administration's position on remedying global warming and ozone depletion, on wetlands protection, and on air pollution legislation. We are told by the White House that Mr. Sununu simply prepares options for the President's consideration and "insures that all points of view are heard." But to my knowledge there is no evidence that the EPA's historic Executive Order ever escaped from the deadly confines of the Domestic Policy Council and reached the President. Perhaps it did, but got lost in his tackle box.

Had Mr. Bush in fact issued the Executive Order proposed by EPA, the country and the world would have been galvanized into action -- but this time, unlike 1970, guided by the only workable environmental strategy: pollution prevention. This would have been a magnificent act of leadership, converting the despair and anguish over the fate of the Earth often voiced by Earth Day participants into a meaningful movement to restore the natural environment. Earth Day cried out for leadership, and EPA's courageous, far-sighted proposal provided the necessary vehicle. In blocking the EPA proposal, Mr. Sununu deprived Mr. Bush of a historic opportunity to lead. And Earth Day, thereby drained of significant content, became only a brief, if noisy -- but unanswered -- outcry for help.

The obstruction of EPA's Executive Order is not only a blow to the Nation's environmental future; it also diminishes the power of American democracy. The demand for real environmental improvement is a national commitment which, as we know, can be realized only by changing the pattern of industrial investment. But these decisions are in private, largely corporate hands, and inaccessible -- thus far -- to the American people. Democracy stops at the door to the corporate boardroom.

The government's massive purchasing power is the only means, at present, of influencing the pervasive corporate decisions that now govern our system of production. This power is an important instrument of American democracy. For the sake of the environment and of democracy itself, it is time that we used it.

INFORMATION NETWORKING FOR POLLUTION PREVENTION

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The networking of "pollution prevention" information extends beyond the normally accepted definitions of "business". The need for educational materials and technical assistance is present in governmental agencies, as well as associations and private citizen groups. The concept of expanding the "business to business" idea to other affected parties gave way to the May 31, 1989 formation of The Alabama Waste Minimization Advisory Committee (WMAC). A brief history of the Committee development was provided in Mr. David Roberson's presentation.

I will focus my comments on the Goals and Objectives of the WMAC and particularly emphasize the committee structure and activities which enhance information transfer. The purpose statement of the committee is to "develop voluntary programs for the minimization of wastes generated in Alabama and disseminate appropriate information to affected groups". Committee objectives under development are listed below:

Waste Reduction Opportunity Assessments
Pilot Projects for Waste Reduction
Technical Assistance Program
Pure Prevention Strategy
Small Business Assistance
Public Awareness Strategy
Success Recognition Program
Long Range Program Support

The WMAC structure was established by soliciting committee members from affected groups, agencies and departments. The Director of ADEM then appointed the members to serve on the Committee which meets on a quarterly basis. The Committee structure is as follows:

Department of Education - 1 member
Department of Economic and Community Affairs - 1 member
Association of County Commissioners - 1 member
League of Municipalities - 1 member
Business Council of Alabama - 1 member
Alabama Chemical Association - 1 member
Public at Large - 2 members
ADEM - Support Staff

Time does not permit for a full discussion of the committee activities, so I will use my time to highlight committee objectives which are extremely visible and positive.

Waste Reduction Opportunity Assessments

The Waste Reduction Opportunity Assessment program also known as The Waste Reduction and Technology Transfer program is rapidly emerging from the development phase to the implementation phase. On May 30, 1990, a Memorandum of Understanding (MOU) was executed with the Tennessee Valley Authority (TVA), ADEM, and Shoals, Incorporated, a not for profit organization chartered in the State of Alabama. This MOU defines the working relationship among the parties as we develop and implement the Waste Reduction Opportunity Assessment program. More specific information is provided in the following text.

Waste assessments, sometimes called waste audits, are an essential component of a waste reduction program. Such audits show where waste reduction methods can be most effective; where they can be used for planning and allocating resources; and where they can be used to measure waste reduction progress.

Utilizing retired engineers and scientists with supplemental assistance and training, provided by the University of Alabama Hazardous Material Management and Resource Recovery Program (HAMMARR), the Tennessee Valley Authority and the State of Alabama are implementing the program elements listed below:

a. recruiting and training retired engineers to conduct waste assessments;
b. conducting on-site waste assessments on a request basis to:
    1. identifing the types and amounts of waste generated in all media by the various processes in the plant;
    2. identifing the major material losses and their causes;
    3. identifing and evaluate potential waste reduction methods;
    4. itemizing current waste management costs;
    5. estimating the cost of different waste reduction practices; and
    6. presenting findings and recommendations to management.

c. identifing needs for technical assistance in basic research for new and improved technology, and applied research to meet pressing and specific needs in industrial by-products and/or hazardous materials management. The needs identified will serve as suggestions for research projects to the HAMMARR program, the

Gulf Coast Hazardous Substance Research Center, and other research organizations.

Education and Public Awareness

Recognizing the need for educational materials, for k through 12, and post secondary education, and the need to educate the general public to increase the overall awareness and understanding of pollution prevention/waste reduction, the State of Alabama utilizes the resources of the Waste Minimization Advisory Committee to:

a. develop a speakers bureau;
b. develop educational/instructional materials for use by speakers;
c. develop and implement procedures to facilitate the sharing of information among organizations represented on the Waste Minimization Advisory Committee;
d. develop and implement procedures to identify existing educational and technical assistance resources, and to make those resources accessible to the member organizations;
e. identify needs for curricula development in k through 12, and post secondary education; and
f. identify and develop strategies for increasing public awareness of pollution prevention/waste reduction.

In summary, I would say that programs for waste reduction or pollution prevention can be developed to fit a wide variety of institutional arrangements. The central theme however should be that tasks can be tailored to each state's specific needs utilizing the resources of both the public sector as well as private enterprise to form a partnership which will lead to a successful program.

FACILITY-SPECIFIC WASTE MINIMIZATION PLANS AT WESTINGHOUSE HANFORD COMPANY

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ABSTRACT

A waste minimization program is required by public law and Federal and State regulations for hazardous waste generators and treatment, storage, and disposal facilities. The U.S. Department of Energy (DOE) has directed its contractors to develop an effective strategy to minimize the generation of hazardous, radioactive, and mixed wastes at the Hanford Site in compliance with State and Federal regulations.

Since Westinghouse Hanford Company (Westinghouse Hanford) has a large and diversified operation, a key component of the Westinghouse Hanford waste minimization program is facility-specific waste minimization plans that document present and future activities to reduce the volume and toxicity of waste generated. Preparation and implementation of these plans will demonstrate facility compliance to Westinghouse Hanford and DOE requirements, as well as State and Federal regulations. The plans include both the goals and the activities for their achievement and provide a basis for evaluation.

Preparation of the plans is divided into two phases. The first phase involves writing the "general" plan that describes the facility operations, the types of waste produced, and the administrative controls used by the facility to ensure waste minimization. The second phase involves a detailed characterization of each waste stream. This characterization includes baselining the quantity of waste generated, brainstorming possible options to minimize waste, and documenting other factors, such as cost and environmental and safety issues, involved with the generation of the waste. This section is ever-changing as more information is obtained and as the waste minimization program evolves.

The general section of the facility-specific plans was prepared by most facilities by December 30, 1989. Phase two, the detailed characterization of each individual waste stream and the setting of goals, has just begun.

INTRODUCTION

A waste minimization program is required by public law and by Federal and State regulations for hazardous waste generators and treatment, storage, and disposal facilities. The DOE has directed its contractors to develop an effective strategy to minimize the generation of hazardous, radioactive, and mixed wastes at the Hanford Site in order to achieve compliance with State and Federal regulations.

The Department of Energy-Richland Operations Office (DOE-RL) manages the activities at the Hanford Site located in southeastern Washington State. Westinghouse Hanford is one of four contractors that currently operate the Hanford Site for DOE-RL. Westinghouse Hanford employs approximately 9,000 people and manages a number of diversified operations:

- Advanced reactor development
- Chemical processing
- Waste management
- Environmental restoration
- Site support services
- Computer and data management.

WASTE MINIMIZATION PROGRAM

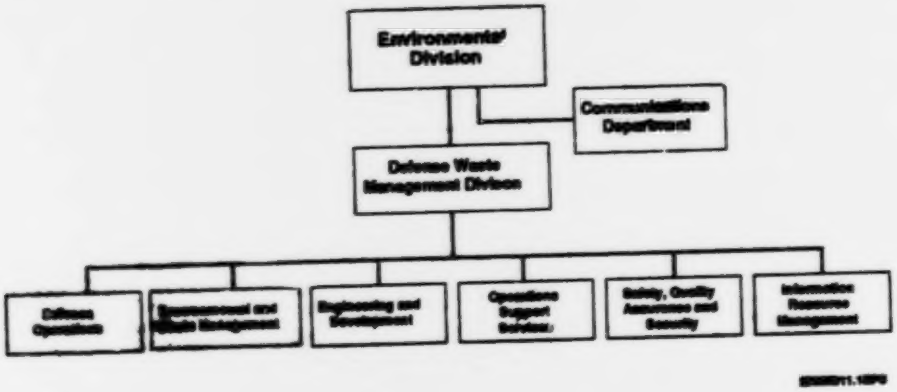
Each DOE-RL contractor has designed and is implementing its own waste minimization program within the structure of DOE-RL's Hanford Site Waste Minimization and Pollution Prevention Awareness Plan. As shown in Figure 1, Westinghouse Hanford's Waste Minimization Program requires support from the Environmental Division, Waste Management Division, Communications

Department, and each facility that generates waste. The Environmental Division, which provides oversight for the Waste Minimization Program, ensures that the program complies with all applicable regulations and DOE orders; verifies that waste minimization is considered in all planning documents, activities, and new projects; and oversees preparation of progress reports as required by the DOE, as well as other Federal and State regulatory agencies.

A Waste Minimization Team has been formed within the Defense Waste Management Division and is chartered to develop, coordinate, and implement a company waste minimization program. The Waste Minimization Team provides guidance to individual generating facilities and develops and implements waste minimization programs that have company-wide applicability and benefits.

Figure 1. Westinghouse Hanford Company Waste Minimization Program

Implementation Hierarchy


Environmental Division
Communications Department
Defense Waste Management Division
Defense Operations
Environmental and Waste Management
Engineering and Development
Operations Support Services
Safety, Quality Assurance and Security
Information Resource Management

The Communications Department is responsible for coordinating the Environmental Awareness Program which includes the training and awareness aspects of waste minimization and pollution prevention, as well as the development of employee incentives and rewards to encourage participation.

Each waste-generating facility is required to incorporate a waste minimization philosophy into its operations. Assessments, priorities, goals, and implementation of waste minimization opportunities are the responsibility of each waste-generation organization. Documentation of these efforts is provided through facility-specific waste minimization plans.

FACILITY-SPECIFIC WASTE MINIMIZATION PLANS

The large and diversified nature of operations within Westinghouse Hanford requires that detailed plans be developed at each waste-generating facility. These plans, entitled Facility-Specific Waste Minimization Plans, document the present and future activities to reduce the quantity and toxicity of waste generated. The facility-specific waste minimization plans are considered "living documents," meaning they are periodically updated to reflect the current status of the facility's waste minimization program. These plans will, therefore, remain in the system as long as the facility continues to generate waste.

To ensure consistency in content and format throughout all facilities, a guidance document for writing waste minimization plans was developed. This guidance document divided the preparation of facility plans into two stages: (1) the program development phase, and (2) the implementation phase. Figure 2 shows an outline of the facility-specific waste minimization plans.

PROGRAM DEVELOPMENT

The body of each facility-specific waste minimization plan is essentially composed of (1) a facility description, and (2) a definition of the facility's waste minimization program structure.

The description of the facility's operations provides background information on the purpose, scope, and scale of work routinely conducted at the facility. The major chemicals and

Figure 2. Facility-Specific Waste Minimization Plan Outline.

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE OF PLAN
1.2 FACILITY BACKGROUND
  1.2.1 Facility Description
  1.2.2 Material Use
  1.2.3 Major Categories of Waste Streams

2.0 WASTE MINIMIZATION PROGRAM

2.1 Waste Minimization Organization
2.2 Responsibilities
2.3 Training Program
2 4 Employee Participation and Incentive Program
2.5 Waste Minimization for New Projects and Designs

APPENDICES

Appendix A Waste Stream Identification and Minimization Potential
  A.1 Origin
  A.2 Regulatory Status
  A.3 Quantity Generated
  A.4 Costs
  A.5 Environmental and Safety Impacts
  A.6 Waste Minimization Potential
Appendix B Goals and Progress Reports
  B.1 Goals
  B.2 Waste Minimization Accomplishments

materials used by the facility are also described here, as well as the types and approximate quantities of waste generated.

The plan defines the structure of the facility's waste minimization program and describes the steps being taken to develop and maintain an effective waste minimization program within the facility. Here, the plan describes the responsibilities of each facility employee with respect to waste minimization and identifies the members of the facility's waste minimization team. Additional topics described in this section of the plan include the facility's training on waste minimization and the use of an incentive program to encourage employee participation. Also discussed are the methods used at the facility to ensure that all new projects and facility upgrades are reviewed with respect to the minimization of waste.

IMPLEMENTATION

Documentation of waste minimization implementation activities consists of two appendices that are updated as information changes to keep the facility-specific plans current. Appendix A of the facility-specific plans provides detailed characterization of each waste stream. The following elements are provided for each waste stream:

- Origin - The process that generates the waste is described.
- Regulatory Status - The waste stream is characterized with respect to hazardous and radiological constituents according to State and Federal regulations and DOE orders. Applicable waste codes are identified.
- Quantity Generated - This difficult but necessary section requires a quantifiable baseline of the quantity of waste generated. Depending on the origin of the waste (e.g., routine operations, equipment decommissioning and replacement, materials and product disposal, or cleanup activities), the method of baselining is different. Waste generated from routine operations may or may not be directly dependent on the production rate. For waste that is related to production, it is important to make this relationship part of the measurement device (e.g., gallons of waste/widget) so that a change in product will not cause a distortion of the measurement. Waste generated from equipment decommissioning and replacement, material and product disposal, or cleanup activities is dependent on the time and funding devoted to perform those activities and, therefore, it is very difficult to determine a meaningful baseline. However, some quantitative measurement is requirement to show the effects, if any, that waste minimization techniques have had on the quantity of waste generated.

- Costs - The costs for managing, storing, and disposing of each waste stream are discussed. This generally includes an estimate of the long-term storage and disposal costs for mixed waste.
- Environmental and Safety Impacts - The potential environmental and safety impacts associated with the generation of each waste stream are identified.
- Waste Minimization Potential - All possible waste minimization opportunities are listed. The U.S. Environmental Protection Agency (EPA) chart on waste minimization techniques is used as a brainstorming tool. Opportunities are investigated for feasibility at a later date.

This characterization procedure is intended to prioritize the waste streams for which the facility should concentrate its efforts. A likely candidate would be a large stream that has several regulated characteristics, may have significant environmental and/or safety impacts, and appears to have several opportunities for minimization.

Appendix B of the facility-specific waste minimization plan is entitled "Goals and Progress Reports." Each facility is required to set annual goals toward waste minimization. The goals may address specific waste minimization implementation ideas or include studies to obtain information for characterizing an individual stream.

Each quarter, the facility representatives report their progress made toward achieving its goals. Annually, at the end of December, the quarterly report also includes an accomplishment report that details the results of waste streams that were successfully minimized. These accomplishment reports are used to prepare reports for the DOE, as well as other State and Federal agencies.

RESULTS

Twenty-nine facility-specific waste minimization plans have been identified to cover all hazardous, radioactive, and mixed waste generated by Westinghouse Hanford. These plans range in complexity from the Hanford Patrol, which generates small volumes of gun-cleaning solvent and rags, to the major chemical processing plants that generate millions of gallons of liquid waste and thousands of pounds of solid waste. The recently strengthened emphasis on environmental cleanup at the Hanford Site is expected to have a major impact on waste management activities. While these cleanup and closure activities will be generating large quantities of liquid, solid, and sludge waste, the potential for minimizing this waste is still present and is being addressed in facility-specific waste minimization plans.

Employee awareness of waste minimization and facility-specific plans varies across the company. Upper management is very supportive of the waste minimization program. Most facilities have jumped into the program eagerly, while some have been slower in responding because of other regulatory requirements and shortage of personnel. Waste minimization teams have been established at many facilities and are meeting on a regular basis. The current emphasis at most facilities is on stream characterization, the development of waste minimization goals, and employee awareness projects.

In one instance, a facility has banned a particularly hazardous product used for radioactive decontamination purposes, because of the inevitable generation of mixed waste. The facility management has offered several nonregulated substitutes to its operators for this task. This banned product is currently used extensively across the company, and other facilities are awaiting the results of the experimentation with the new substitutes so that they can substitute nonregulated products into their processes.

Facilities are active in cleaning out their old products and unknown chemicals. While this is generating large quantities of waste at the present, better inventory practices and management procedures will hopefully prevent the situation in the future. A sitewide chemical exchange has been initiated to assist facilities in finding users for chemicals they no longer need. This is intended to save on purchase costs, as well as to provide a significant savings in waste disposal.

Several facility representatives have joined together to work on common problems. The first task team is investigating degreasing agents in search of an effective substitute for hazardous products currently being used.

Westinghouse Hanford is assisting facility efforts by providing forums for facility representatives to exchange ideas. Informational mailings are also used to communicate activities and successes of other organizations both onsite and offsite. Facilities are being encouraged to show company-owned commercial videos on waste minimization to their employees in an effort to educate and spark interest in their facility-specific programs.

One major element missing from the facility-specific plans is a method to evaluate potential waste minimization opportunities. It is important that each potential solution be fully evaluated and tested before implementation. This has not posed a problem yet, but is an area that will need to be addressed in the near future.

CONCLUSION

Facility-specific plans provide a method for bringing the responsibility of waste minimization to those best suited to produce results. However, the process takes time. Employee awareness and education play a key role in the success of a waste minimization program. This awareness and education must be directed to *each* employee, from the company president to the personnel who work with budgets, procurement, who work in offices, and who directly generate waste. Few can argue the benefits of minimizing waste when they understand the process and why it is necessary.

A major concern at Westinghouse Hanford continues to be the development of effective baseline generation values with which to measure waste minimization or reduction successes. Regulatory reports require quantitative results for waste that has been minimized, and the future hints at required percentage reductions through State or Federal avenues. Without an effective baseline for the waste that is currently being generated, it is impossible to prove that minimization has occurred. The tie to production is necessary whenever possible, and Westinghouse Hanford is finding that the majority of the waste generated *cannot* be tied to a production ratio.

Although no waste minimization program can be effective without involvement by the people working directly in processes that generate the waste, strong company-wide programs, such as employee incentives and rewards, chemical exchange, recycling, and procurement control, are also necessary to support the detailed facility-specific efforts. Westinghouse Hanford recognizes the long-term benefits from minimizing the waste we generate, and we believe we have a strong program that will lead to success.

EUROPEAN EXPERIENCES IN STIMULATING CLEANER TECHNOLOGIES

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INTRODUCTION

Growing awareness of environmental degradation has led to many European countries placing increased emphasis on the development and implementation of cleaner technologies. Leading countries in this respect are particularly the Scandinavian countries, the Netherlands and West-Germany. By 'cleaner technologies' we mean the whole spectrum of add-on, pollution abatement technologies versus integrated, low-emission production technologies, designed to avoid most of the pollutants at the source (including changes in both process technology and product substitution). The direct, more structural government interference with cleaner technologies started in various European countries in the mid 1970s. A series of specific measures were introduced to encourage industry to adopt cleaner technologies: financial assistance, research and development programmes, dissemination of technical information, adapting regulations to favour cleaner technologies, etc. This paper aims to summarize the experiences gained particularly in the various Northern-European countries in stimulating cleaner technologies and discuss the possible ways to proceed. An important element in promoting cleaner technology is the focus on the whole product's life-cycle and the measures which could be taken to increase the awareness of the environmental aspects of the product's history and the environmental consequences of its use. In this context special attention will be paid to 'Environmental Product Information-Exchange' (EPIE) and the 'Environmental Product Profile' (EPP). It will be discussed whether such information could be used as a policy tool. In evaluating the European experiences use will be made of various reports on this topic and in particular of the conclusions drawn at the recent ECE seminar on 'Economic Implications of Low-Waste Technology', held in The Hague (the Netherlands) in October 1989.

PRACTICAL EXPERIENCES WITH CLEANER TECHNOLOGY POLICIES

In promoting the development and implementation of cleaner technologies most European countries have traditionally devoted a great deal of attention to the use of legislated, regulatory measures, coupled with a system of monitoring and sanctioning non-compliance. Although direct regulations have enabled government authorities to control the behaviour of industries to a large extent, this form of regulation does have a number of limitations. The costs of developing and enforcing regulatory programmes are high and it takes a long time before new regulations can be implemented in practice. In addition, many countries lack a sufficiently developed infrastructure to control the implementation of appropriate legislative provisions and related regulations. Moreover, the prevailing single-media oriented environmental legislation inhibits the integration of legislation directed towards pollution prevention. Finally, the kind of mechanical command-control relationship, in which the government tries to force industries to meet certain emission standards, often restrains industry to play an active role in developing and implementing preventive technologies. As a result regulatory measures have mainly led to the application of add-on pollution control equipment and far less to process-integrated technologies and product-substitutions.

In order to overcome the limitations of regulatory programmes, several European countries have developed additional measures, especially in the form of economic incentives or disincentives. These include incentives in the form of loans, subsidies, tax relief and exemptions, grants, etc. or disincentives in the form of taxes, fines, charges, performance bonds, etc. In contrast to the United States European countries did not intervene in the market structure by allowing a trade in pollution rights (bubbles, offsets, netting and banking). Only minor applications are seen in Germany (1).

Generally speaking, until now only limited use has been made of the various economic instruments. Given that charges and subsidy funds are the most often implemented economic instruments to stimulate cleaner technologies we will dwell below in some detail upon the experiences gained in Europe with these particular instruments.

Charges, particularly effluent and user charges, have been introduced in various West-European countries but often without much incentive impact. These charges were often too low and mainly directed at raising revenues to cover the costs of the services involved. Effluent charges were generally introduced in connection with issues of water- and air-pollution. User charges are more common as regards the collection and treatment of municipal solid waste and waste water discharged into sewers.

More and more attention is being given to product charges, for instance on fuel (e.g., the Netherlands), packaging (e.g., Denmark), certain batteries (e.g., Sweden), waste oil (e.g., Finland), non-refillable containers (e.g., Norway) and carbon dioxyde (e.g., the Netherlands). Some countries, including the Netherlands, are considering the extension of the number of years thereafter.

Experiences have learned that the application of economic instruments, in particular charges and financial aid programmes, may have an incentive impact on the promotion of cleaner technologies, if properly applied and used in combination with other instruments. However, similar to the experiences with legal instruments both charges and financial aid programmes have also led mainly to the development of end-of-pipe, curative technologies, while investments in preventive technologies lagged behind. Due to the government's focus on a short term environmental policy, most attention has been paid to the solution of acute, environmental problems. This has led to a reactive, effect-oriented policy aiming at the elimination of the environmental effects mainly through the establishment of technical standards. In order to meet these standards industry could suffice by implementing additional end-of-pipe technologies.

ADJUSTMENT OF PRESENT LEGAL AND ECONOMIC INSTRUMENTS

To facilitate the promotion of cleaner technologies various suggestions have been made to adjust the legal and economic instruments presently used. Most of these suggestions, however, have often not been put into practice yet. Let us give some examples.

ADJUSTMENT OF LEGAL INSTRUMENTS

With respect to legal regulations it is proposed to modify, where necessary, the implementation of legal regulations through improvements and greater flexibility giving industry more latitude in its technological policies (4). Experiences have learned that strict regulation coupled with a flexible implementation can lead to the desired changes. If, for example, it is unclear whether and how the government will adjust its regulations in the near future, industry will tend to react rather conservatively and will postpone major investments in production modifications. On the other hand, a timetable for alterations in rates covering a sufficiently long period would enable industry to take appropriate action in full knowledge of the facts. In this way the government can, so to say, 'force' the introduction of cleaner technologies. Independent research-institutes can play an important mediating role in this process.
One of the major obstacles in realizing this suggestion is the enormous differences in environmental standards and the respective environmental administration systems in the various European countries. Thereby the force of introducing or implementing cleaner technologies differs considerably too. Countries with strict environmental standards tend to take the lead concerning the development of cleaner technologies (5). How this situation will change after the establishment of the Internal EC Market in 1992 cannot be predicted. Fear exists that the EC environmental policy tends to

water down legislation to the lowest common denominator of the policies of the EC Member States. Under the present structure of EC decision-making only a greater overall commitment to EC environmental policy on the part of all Member States could lead to stronger legislation (Bartle, 1990).

Beside the greater flexibility, existing legislation and regulation practices should also be examined and modified, aiming at ensuring integrated pollution control based on the concept of low-waste technology. To this effect, the following legal and administrative measures were proposed at the recent ECE Seminar on Economic Implications of Low-waste Technology (16-19 October 1989, The Hague, the Netherlands). These measures should:

a) contain provisions to promote the application of the low-waste concept at the earliest phase of production/consumption processes, e.g. at all planning and design stages in the product's life-cycle, namely manufacturing processes, use and disposal, in order to minimize waste/pollution generation and its environmental impacts. An example of such provisions is the obligation to carry out properly defined environmental audits which should be included in plant licenses, regulations or other appropriate legal instruments.

b) provide for the analysis and evaluation of possible environmental impacts of activities and related technological options in the construction, operation and abandonment phases. This may involve rethinking a process to seek an alternative method of operation using environmentally sound technologies with due consideration being given to the need for mitigation and compensation for environmental damage.

c) tighten responsibility and liability regulations for all societal actors to play a forceful anticipatory role, including preventive duties, through wider implementation of low-waste technology. Especially industry could use such a concept as a tool to predict future expenditures related to responsibility and liability questions. There is no doubt that the risk of having to pay could be reduced by the progressive adoption of low-waste technology.

ADJUSTMENT OF ECONOMIC INSTRUMENTS

Governments can also improve the use of economic instruments (particularly charges and financial aid programmes) to promote cleaner technologies. At the ECE seminar on 'Economic Implications of Low-Waste Technology' it was recommended that charges (on e.g. polluting techniques, products, raw materials or social activities) should meet certain requirements in order to be effective. They should be reasonably high, set for a considerable period of time and aimed at specific environmental objectives. The role of subsidy programmes in stimulating cleaner technologies can be reinforced as well. At the ECE seminar mentioned above it was, for example, concluded that financial aid programmes for R&D in cleaner technologies must be efficiently administrated and co-ordinated with other forms of financial assistance and the main components of environmental policy. At present R&D funds are often insufficiently directed towards long-term, internationally co-ordinated programmes focusing on cleaner technologies.

Moreover, efforts must be made to improve the access to aid for small and medium-sized firms, which at present receive only a very minor part of the aid.

In principle, aid for pollution control may also have an incentive impact on the promotion of cleaner technologies. However, doubts were raised at the ECE seminar about the effectiveness of providing such investment grants. As long as firms are not interested in applying low and non-waste technologies, grants often seem to be a waste of money, whereas, if they are willing to make use of such technologies, they will usually do so even without financial aid. Despite this general scepticism some exceptions should be mentioned. In the case of urgent environmental problems, for example, financial aid or cost-sharing arrangements can be effective, in particular for smaller firms. It is also true that subsidies reduce the economic risks inherent in developing process-integrated technologies and product-substitutions. They can therefore be beneficial if granted subject to stringent conditions (7).

To sum up, it can be stated that one of the major problems facing European governments at present is to find out how they can best induce the industrial sector to change over to preventive technologies instead of favouring add-on technologies. In order to use governmental policy instruments more efficiently in developing cleaner technologies the necessity was stressed at the ECE seminar on 'Economic Implications of Low-waste Technology' to broaden the present regulatory perspective and reorient it towards an environmentally sound business strategy for enterprises. The need was expressed of integrating environmental policy with economic policies in general and industrial policies in particular.

The starting-point of this broader technology policy should no longer be solely the Government, who must work for a cleaner environment mainly through regulation. Governments should also promote a greater environmental responsibility on the part of producers and consumers. Therefore pollution prevention does not exclude the application of other policy measures, mainly of an educational nature, for promoting new life-styles, changes of patterns of consumption and production and alternative forms of organization of social life. For the purpose of illustration we will present below two examples of new policy measures European governments are developing to enhance the environmental responsibility among producers.

THE PROMOTION OF ENVIRONMENTAL RESPONSIBILITY AMONG PRODUCERS

In Europe there is a growing tendency to extend the producers' responsibility from the manufacture of products to the whole life-cycle of the product, including recycling, recovery, re-utilization and disposal of the product and related materials (e.g. packaging). In order to promote this responsibility several measures are being proposed. At the recent ECE seminar on 'Economic Implications of Low-Waste Technology' major attention was paid to: a)the institutionalization within enterprises of environmental care; b)the development of guidelines for 'Environmental Product Information-Exchange' and 'Environmental Product Profiles'.

inform each other about the environmental aspects of their products. Certification-systems do exist with respect to products and production processes within the framework of quality care (including health and safety). Moreover, various countries (following in the footsteps of West-Germany) are engaged in developing product-information for consumers (environmental labelling) (8) (9). These forms of information-exchange about environmental aspects of (half)products have hardly got off the ground among producers.

In order to improve this situation, information about the environmental aspects of the whole product's life-cycle, including the environmental consequences of its use should be communicated among manufacturers by means of an 'Environmental Product Information-Exchange' (EPIE) or sometimes called 'Environmental Product Declaration' (EPD). At the ECE seminar on 'Economic Implications of Low-Waste Technology' it was recommended that such an information flow needs to be set up in a systematic way following harmonized procedures which are based on compatible criteria and principles to establish an environmental product profile (EPP) as well as an environmental technology profile (ETP).
The Environmental Product Information-Exchange should be preventive and stimulate the manufacturers to develop products with improved environmental properties. The mere fact that environmental product information should be presented by all manufacturers of all products would be an incentive to avoid unnecessary negative qualities being associated with the product. The EPIE should also guide importers, wholesalers and retailers and in this way help to secure good marketing of the products. Products with good environmental standards could certainly be a way to strengthen the goodwill of the company and thus help ensure long-term corporate profitability (10).

In principle, a complete 'Environmental Product Information-Exchange' or 'Environmental Product Declaration' may contain the following parts (11):
1) a list of all environmentally relevant substances (elements and compounds), which are present in the product;
2) an account of all stages in the production process, which are of importance to the environmental properties of the product;
3) an account of the final treatment of the product;
More complex products may be supplemented with
4) a dismantling/scrap declaration;
5) a repair declaration.

However, it may be questioned whether the exchange of such detailed information will always be useful. Whether, and if so, which kind of product information-exchange among producers is worthwhile, will depend on a variety of factors, such as:
- the kind of relationship/cooperation between the particular customer and subcontractor (in the case of a close cooperation and professional negotiation-structure EPIE may be a rather crude instrument in a delicate process);
- the chain in the particular production-column where the exchange of information between customers and subcontractors occurs;
- the available environmental expertise among those concerned;

- the availability of an elaborated environmental product profile (EPP) and environmental technology profile (EPT);
- the diversity of (half)products with which customers have to deal;
- the interactions within the particular firm (e.g., the relation between the buying department and the environmental care department; the management and the employees, etc).

Governmental authorities who will play an important role in issuing guidelines for the EPIE should take into account the considerations mentioned above. They need to differentiate the requirements for an EPIE according to the needs of the manufacturers involved. It will, for instance, not always be necessary to make it obligatory to print in full the complete EPIE on the product or even on the packaging. Which combination of information exchange will be the most useful is still an open question. One could think of a combination of some form of environmental labelling and certification-system with a fairly complex and elaborate EPIE. Further details should, however, still be worked out.
In order to avoid the uncontrolled spreading of environmental messages and logos, the requirements of EPIEs should be well regulated by governments and internationally harmonized. To that effect, the ECE has recently set up a Task Force, in which the Netherlands will play an initiating role. If this Task Force is successful EPIEs can form an important additional policy instrument to stimulate the development and marketing of cleaner products and in this way broaden the set of instruments used at present.

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EVALUATION OF EPA WASTE MINIMIZATION ASSESSMENT

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ABSTRACT

EPA's research efforts to encourage the use of waste minimization opportunity assessments is presented in this paper. The early stages of EPA research centered on the development of the EPA-recommended procedure for conducting an assessment, and its use at a number of facilities. This paper will demonstrate the value of the waste minimization assessment for discovering and developing opportunities to minimize wastes by presenting briefs on assessments recently conducted at several private concerns.

These private concerns include a photo lab, a truck manufacturer, a large church facility, a nuclear power generation facility, and a graphic controls manufacturer. These assessments are at various stages of completion. The status and results of each assessment are presented.

Based on completed assessments and discussions with company representatives, the EPA-recommended procedure as described in the "EPA Waste Minimization Opportunity Assessment Manual" is evaluated for its usefulness. Reluctance in initiating an assessment has been encountered, but when technical support was provided to conduct an assessment, company representatives expressed strong satisfaction with the results.

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

INTRODUCTION

While the word "assessment" often raises the fear that what is being talked about is an environmental audit, the assessment team is not looking for incidences of facility non-compliance. Their purpose is to examine a process and its components for inspiration to develop techniques that would enhance the cleanliness of a particular process or operation. To accomplish this goal, certain team members must have technical background appropriate to the type of process they are assessing. Therefore, a knowledge of RCRA compliance and SARA Community Right-to-Know regulations is not required of the assessment team.

Conducted by an in-house team or with an independent outside consultant, a waste minimization opportunity assessment (WMOA) is simply a structured review of a process or operation to lead to identified opportunities for waste reduction or recycling. Its focus can be broad or narrow. Often, it is more effective to select a few areas for intensive assessment than to attempt to cover all waste streams and processes at once.

The EPA has published "The Waste Minimization Opportunity Assessment Manual" (EPA/625/7-88/003) for conducting a waste minimization assessment. This manual is available at no cost from the EPA's Pollution Prevention Research Branch, Cincinnati, Ohio 45268. The procedure recommended in the manual is outlined in Figure 1. WMOA's are an extremely effective way to improve a facility's operations, from both an economic and environmental standpoint.

The following sections on industry assessments, "church assessments", and New Jersey assessments represent descriptives of some of the assessment efforts currently being conducted by the EPA.

INDUSTRY ASSESSMENTS

The focus of the industrial assessments effort has been on locating small and medium-sized facilities which may not have the immediate resources or expertise to do what is necessary to reduce their waste, and would benefit significantly from Agency support. Toward this goal, assessments have been conducted at a mini-photo lab and a truck manufacturing facility. Both hazardous and non-hazardous wastes are included in the assessments.

Details on the mini-photo lab and the truck manufacturer assessments are provided below.

MINI-PHOTO LAB

After an assessment in August 1989, the assessment team identified five waste minimization options they considered applicable to the waste-streams of interest. Following is a brief description of these options.

Option 1 - Wash Water Control - Wash water is used for color film development and the B&W paper process. The wash water is turned on each production day at approximately 7:00 a.m. and shut off at 7:00 p.m. Water use is therefore continuous during the day, however, production is not. The waste minimization option consists of a simple timer control system consisting of a switch, timer and solenoid valve. The operator would punch a button on the switch to activate the timer. In turn, the activated solenoid would allow water to flow for a preset time period.

Option 2 - Silver Recovery/Metal Replacement Cartridges - Silver is found (as light-sensitive silver halide) in spent photographic chemicals and wash waters as a result of removing the emulsion on films and papers. A metal replacement cartridge is a widely-used device for silver recovery. It can be used alone or in conjunction with other recovery technologies. In this case, the spent process solutions which contain significant amounts of silver would be plumbed to a single pipe. Two cartridges would be used to allow for high capacity while maintaining a high recovery rate.

Option 3 - Silver Recovery/Electrowinning - An electrowinning unit passes a direct current through a concentrated silver solution from anode to cathode causing the silver to plate out onto the cathode in nearly pure metallic form. A wide range of equipment is commercially available for electrowinning. Using manufacturer's literature as a basis, it is expected that up to two batches (4 gallons each) can be treated each day. During the average batch, 1.13 troy oz. of silver would be recovered within 4.5 hours.

Option 4 - Silver Recovery - This option is based on using the electrowinning device in Option 3, with metal replacement cartridges used to polish the effluent. The average effluent will be desilvered from 500 mg/l to approximately 10 mg/l, using only one cartridge.

Option 5 - Bleach Fix Recovery - The recommended method for bleach fix recovery is desilvering with two metal replacement cartridges. This requires three steps: 1) silver recovery, 2) restoring bleaching ability by aerating ferrous-EDTA complex to oxidize back to ferric-EDTA, and 3) replenishment of chemicals lost through carry-over with the film or paper. Approximately 75% of the recovered bleach fix solution can be reused while 25% should be discarded to prevent contaminant build-up.

Total capital investment, net operating cost, and payback period for each option are shown in Table 1. The owner of the lab has received a copy of the final assessment report and is taking the recommended options under advisement.

TABLE 1. SUMMARY OF MINI-PHOTO LAB WASTE MINIMIZATION OPTIONS

WASTE MINIMIZATION OPTION	TOTAL CAP. INVESTMENT, $	NET OP. COST SAVINGS, $/YR	PAYBACK PERIOD, YR
Wash Water Control	$ 675	$ 1,436	0.47
Silver Recovery Using Metal Replacement Cartridges	1,071	1,325	0.81
Silver Recovery Using Electrowinning	3,510	1,414	2.48
Silver Recovery Using Electrowinning with MRC Tailing	3,667	1,757	2.08
Recycle of Bleach Fix and Silver Using MRCs	1,571	2,508	0.63

TRUCK MANUFACTURER

This truck manufacturing facility produces 34 trucks (tractor-trailer) per day. The production processes are primarily assembly and painting. The current quantities of generated wastes and the associated disposal costs for the first three quarters of 1989 are given below:

	Amount (lb)	Cost of Disposal
Waste Paint	184,860	$12,957
Pretreatment Sludge	71,020	$ 9,134
Undercoating	3,375	$ 2,560
Degreasing Solvent (Chlorinated)	13,060	$ 5,431
Used Oil	28,275	$ 105
Paint Sludge	474,960	$15,132
Housekeeping	3,800	$ 1,428

The above figures represent a sharp decrease from recent years. The facility has instituted a number of waste minimization measures and cost reduction methods related to good waste management practices.

A site visit was conducted in January 1990 to begin the assessment. Although this facility has made major strides in waste minimization, the assessment team feels there are additional opportunities which may have significant impact. The following are targeted areas which will be investigated further throughout the assessment and feasibility phases.

Spray Painting - Air-assisted airless spray equipment is used for most spray painting. This method is a distinct improvement over conventional compressed air spray painting, however, alternatives exist which may improve transfer efficiency. Increasing the transfer efficiency reduces the volume of paint used and reduces volatile organic carbon (VOC) emissions.

Phosphating - An automated phosphating (conversion coating) process and electro-coat (E-coat) is used for small and medium-sized parts. This line consists of several processing and rinsing steps. The rinse water is piped to a chemical treatment plant where it is combined with paint booth wastewater. The resultant sludge is disposed as a hazardous waste.

It may be possible to avoid waste treatment of the phosphating rinse water by using an ion exchange recycle system, thereby also reducing water usage. Furthermore, the current wastewater treatment process, which uses large amounts of ferric chloride, may be altered, resulting in reduced sludge generation.

Degreasing of Rail Frames - The rail frame, or chassis, is degreased prior to spray painting using a chlorinated solvent (90% 1,1,1,-trichloroethane/10% methylene chloride). The spent solvent is distilled (350-400 gallons per day) and reused. Waste minimization options may include chemical substitution, procedural changes, or improvements to the recycle process.

The assessment team is completing the feasibility phase and a draft report is expected in May 1990.

CHURCH ASSESSMENT

This study of a church facility looked at daily office operations, special functions, general maintenance and an on-site pre-school. As would be expected, churches are not normally large waste sources, however, they are a tremendous source of social awareness. It is anticipated that this assessment and suggestions for waste minimization will result in widespread distribution through the church's governing bodies and congregation. This information will impact not only other churches, but also people's activities at home and at work.

The location of the church assessment was the Mt. Washington Presbyterian Church (MWPC) which is about fifteen miles east of downtown Cincinnati. With a 1990 budget of $615,000 and a $3,000,000 renovation and expansion project, this 2,000 member church represents a substantial institutional facility. The church has a very aggressive Recycling Committee which has been active in collecting recyclable material for the community.

The site visit was made in December 1989. The specific areas of concern included building and grounds maintenance, pre-school, social activities, kitchens, administrative offices, and new building expansion.

Predictably, the largest waste generated by the church is white paper. However, there are numerous other cleaners, paints, lawn materials (e.g., weed killer), etc., that are used in significant quantities. The final report describing waste minimization options is expected to be available by the summer of 1990.

NEW JERSEY ASSESSMENTS

A pilot project with the New Jersey Department of Environmental Protection (NJDEP), entitled "Assessment of Reduction and Recycling Opportunities for Hazardous Waste (ARROW)," will allow the State to evaluate waste minimization techniques and conduct assessments at approximately thirty facilities within New Jersey. The objective of the site selection is to cover ten industries (three sites in each) to develop industry-specific information through the assessment activities.

Through a subcontract with NJDEP, the New Jersey Institute of Technology (NJIT) is locating sites and performing the assessments by following the EPA-recommended procedure outlined in the EPA manual. Participation in the program by facilities is on a voluntary basis. To date, response to the program has been enthusiastic and 14 companies are lined up for assessment work. Four site visits have been completed and the assessment reports are being prepared. Brief descriptions of two of the companies visited and potential waste minimization options follow below.

NUCLEAR POWER GENERATION FACILITY

Interestingly, the bulk of the wastes from this electrical power generation facility is from construction and maintenance activities when power generation is shut down. Three major sources of waste streams were identified by the assessment team: operations, maintenance, and site services. After analysis of costs and waste generation quantities, the assessment team targeted opportunities for reduction in the levels of off-spec materials and containers of partially used materials which go to waste treatment and disposal. Several waste reduction options were identified, such as improved project estimation and planning of material procurement, dispensing, and stocking; incentives to contractors for waste reduction; and improved security to protect against wastes imported to the site.

GRAPHIC CONTROLS MANUFACTURER

This facility manufactures pens and markers for automatic recording devices and inks for use in these devices. The waste generation data indicate that the operation for ink formulation and preparation contribute to the bulk of the hazardous waste generation. Some options leading to reduced waste generation include reduction in quantities of rinse water used in the cleaning of equipment; improved scheduling of colors and types of batches of inks to reduce cleaning between batches; increased use of mechanical cleaning of tanks to supplement water cleaning; and changes in ink preparation procedure such as the utilization of a large ink base which could be tinted to the appropriate color in smaller batches as the need arose using small amounts of tinting color.

NJIT continues to work with facilities who show a strong interest in waste minimization and have volunteered to participate in the ARROW program. This effort will continue through August 1991.

ASSESSMENT PROCEDURE EVALUATION

The EPA's assessment procedure itself is of interest regarding its usefulness in identifying waste minimization opportunities. As expected, this issue is difficult to quantify, however, some general comments on the effectiveness of the manual can be made from the assessments that have been completed within the EPA's waste minimization opportunity assessment program.

Discussions between EPA contractors performing waste minimization opportunity assessments and company representatives led to identifying three issues on how a company may be delayed in initiating an assessment effort. These three issues are as follows:

1) Implementation of the Manual's procedure is based on the establishment of firm corporate commitment. This commitment is needed in order to devote necessary time and resources. Management may not be approachable if specific information is not available to them on what the company can expect in return for their investment.

2) To someone who is not familiar with the manual, it appears cumbersome and lengthy and looks like a lot of work in filling out the forms. This impression may cause users to lay the Manual aside until a later time. The user may or may not return to the Manual.

3) Occasionally there is the fear that the completed manual forms would become available to the regulatory agencies and become incriminating information. This unfounded fear prevents people from filling out the forms which is a critical step in understanding a facility's waste generation and management practices.

In situations where outside assistance was received in performing assessments, company representatives expressed strong satisfaction with the results. They perceived the amount of time involved in the exercise to be appropriate. The most valuable result was the identification of ways to lower costs, which in turn helped convince management of the profitability to be incurred in an effective waste minimization program.

It is reasonable to conclude that many manufacturers recognize their waste generation problems and have undertaken actions to address and improve them. Toward this end, they are very receptive to any method such as the one presented in the Manual which will assist them in meeting their waste management objectives.

CONCLUSION

This paper describes several waste minimization success stories arising from the EPA's Pollution Prevention Research Branch in Cincinnati, Ohio. The programmatic approach has been to go to industry to determine the manual's implementation and to transfer technical pollution prevention impacts throughout the community, especially to small and medium-sized businesses which may not otherwise have the resources to pursue pollution prevention initiatives on their own. Furthermore, it is clear that EPA's program has focused on practical approaches to already existing processes and facilities. Such an approach begs the question: What about the future?

EPA's assessment program will continue to aid in the establishment of a knowledge pool of individuals technically-oriented to pollution prevention. The assessment process is becoming an integral part of business management practices, much as safety concerns have become routine. Beyond these assessments, the Agency's pollution prevention research programs must turn to identifying clean practices, clean products and processes. With the cooperation of representatives from private concerns, EPA anticipates broad potential for research in alternative technologies and products that lower risks to the environment and our future heritage.

WASTE REDUCTION EVALUATIONS AT THE PHILADELPHIA NAVAL SHIPYARD AND FORT RILEY, KANSAS

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This paper describes two case studies funded by EPA's Waste Reduction Evaluation at Federal Sites (WREAFS) Program. This program consists of a series of demonstration and evaluation projects for waste reduction conducted cooperatively by EPA and other Federal agencies. The case studies described herein were performed at the Philadelphia Naval Shipyard (PNSY) and Fort Riley, Kansas, and included the following industrial processes: metal cleaning, spray painting, bilge cleaning, and vehicle maintenance operations. The work included a survey of the industrial operations, data collection efforts, the identification and evaluation of waste minimization (WM) options and development of WM recommendations. The procedures employed during these projects were patterned after EPA's Waste Minimization Opportunity Assessment Manual.

The project at PNSY was performed by Science Applications International Corporation (SAIC) under contract to EPA (Contract No. 68-C8-0061). The Fort Riley project was conducted by Versar, Inc. under subcontract to SAIC. This paper extracts information contained in the Project Summary Reports developed by EPA's Risk Reduction Engineering Research Laboratory, Cincinnati, Ohio.

INTRODUCTION

The purpose of these projects was to develop waste minimization (WM) plans for specific processes at the Philadelphia Naval Shipyard (PNSY) and Fort Riley using the Environmental Protection Agency's (EPA) Waste Minimization Opportunity Assessment Manual. This manual provides a systematic planned procedure for identifying ways to reduce or eliminate waste. The development of this procedure was supported by the Risk Reduction Engineering Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

Each project was initiated with a meeting at the site to organize the project team, discuss the planned approach, and to select several industrial processes for evaluation. This meeting was also used as a starting point for applying the waste minimization assessment procedures. These procedures consist of four major steps: 1) Planning and Organization - organization and goal setting; 2) Assessment—careful review of a facility's operations and waste streams and the identification and screening of potential options to minimize waste; 3) Feasibility Analysis—evaluation of the technical and economic feasibility of the selected options and selection of options for implementation; and 4) Implementation—procurement, installation, implementation, and evaluation. This project completed much of the first three steps of the procedures for several selected industrial activities.

PHILADELPHIA NAVAL SHIPYARD

The PNSY project was conducted in cooperation with the Environmental Safety and Health Office of the Philadelphia Naval Shipyard. The Shipyard has an on-going program for waste minimization. With their guidance, several industrial operations were selected for application of the new waste minimization procedures. The Shipyard plans to utilize the results from this project as a guidance tool for evaluating waste minimization opportunities at other industrial activities at the PNSY.

The following three industrial areas at the PNSY were selected for evaluation during this project.

- Building 990 - Aluminum cleaning and spray painting
- Citric Acid bilge cleaning operations conducted in drydock

The assessment phase of the project was initiated with a three-day survey conducted by engineers from SAIC and supported by the Environment, Safety and Health Office, with cooperation from other affected departments at the PNSY. The survey focused on the collection of process and waste data and the identification of procedures for waste management. The survey was concluded with a briefing of the PNSY Production Officer.

DESCRIPTION OF AREAS SELECTED FOR WM ASSESSMENT

The industrial activities selected for this project include Building 990 where fabrication and surface coating of aluminum products is performed and the citric acid derusting operation which is located at the drydocks. The following is a short description of these operations.

Building 990

An aluminum cleaning operation is performed to remove oil and other materials from the surfaces of aluminum sheets. The cleaning line consists of four tanks: two process tanks and two rinse tanks. The cleaning procedure consists of loading aluminum sheets into a metal basket, hoisting the basket into a process tank (5 min.), and rinsing in one of the rinse tanks. The process tanks contain a proprietary cleaning solution. One of the process tanks is heated (steam coil) and the other is at ambient temperature. The heated tank is used more often since it provides better oil removal. The rinse tanks contain tap water. Both rinse tanks are heated.

The process tanks become diluted after repeated operation due to dragout losses and tap water replenishment. These tanks also collect floating oil, and the solution becomes contaminated with suspended solids. After approximately three months of operation, the process tanks are pumped to a tank truck and contractor hauled to disposal.

The rinse tanks are operated as nonflowing rinses. This is due to the low pH of the rinse water and the lack of facilities for neutralization. The rinse tanks are disposed in the same manner as the process tanks, but on a more frequent schedule, usually every two weeks.

During this project, drag-out reduction methods and an alternative rinsing procedure were evaluated which would reduce the frequency of discharge for these wastestreams.

A spray painting process is present in Building 990 which is used for small and medium sized aluminum parts. Aluminum parts are degreased by wiping with rags that have been dipped into xylene. The parts are then spray painted in a water curtain booth. The painting process typically consists of a zinc chromate primer, air drying, a final enamel paint coating, and air drying. A new booth water chemical system was used for the first time during the survey. The new process has been investigated and selected by the PNSY.

The new process consists of several steps. Initially, a booth cleaning chemical is used to remove overspray and paint sludge from the booth surfaces. These paint solids are removed and drummed and the booth water is discharged to the sewer. This cleaning process will be scheduled every six months. After cleaning, the booth is refilled with fresh water and a detackification chemical is added along with a buffer. The detackification chemical is an organic polymer which causes the paint overspray to form a fine colloidal precipitant, which is dispersed throughout the booth. The buffer maintains the optimal pH for precipitant formation. In this form, the paint particles do not clog the booth water recycle spray nozzles or piping system and tend not to adhere to booth surfaces. After approximately two weeks of operation, a second organic polymer is added which coagulates the dispersed paint into a floating mass or sludge. This sludge will be removed by screening and drummed for disposal. The booth water can be reused after the addition of more detackification chemical. After approximately six months, the system is cleaned using the initial procedure.

The economics of the new booth maintenance system were evaluated during this project. Also, optional dewatering equipment was evaluated which is currently under consideration by PNSY. The dewatering equipment will reduce the volume of paint sludge generated by the maintenance system.

Citric Acid Bilge Cleaning

PNSY employs a chemical cleaning process for ships' tanks, bilges and void spaces termed the citric acid process. It is generally performed while ships are in drydock. This process is relatively new (1976) and it replaces the mechanical methods of cleaning and derusting metal surfaces. The procedures involve the use of a citric acid/triethanolamine (TEA) solution to remove the oxides from the metal surfaces, and subsequent neutralization and rinsing with dilute solutions.

The volume of spent solutions from a bilge cleaning operation is typically about 3,000 gal. This solution generally has a pH below 4.0 and contains toxic metals. It is contractor hauled to treatment/disposal.

WASTE MINIMIZATION OPTIONS

The project team identified seven WM options that were considered applicable to the wastestreams included in this study.

Option 1 - Dragout Reduction and Bath Maintenance for Al Cleaning Line

The Option 1 system includes a hand-held spray rinse which will be applied over the process tanks. After impacting the basket and parts, the rinse water will drip into the process tank. The spray rinse is expected to return 90% of the dragout back to the process tank. The amount of rinse water that can be used will depend on the evaporation rate of the process tanks. This rate is expected to be in the range of 4-8 gph per tank.

The acid baths accumulate oil from the parts and solids from the parts and surrounding air. Returning dragout losses to the tank will cause the process tanks to accumulate contaminants at a faster pace. These contaminants may interfere with the cleaning process. Therefore, a bath maintenance system is recommended. This system includes an oil skimmer for floating oil and grease removal and a cartridge filter for suspended solids removal.

Option 2 - Two Stage Rinse for Al Cleaning Line

Rinsing is presently performed in stagnant tanks that are pumped and contractor hauled every two weeks. The proposed system would employ a two stage rinse.

Option 3 - Paint Booth Chemical System

The Chemical System consists of 3 phases: a biannual cleaning, normal operation, and biweekly paint removal. The system is currently being used on a trial basis in the Building 990 paint spray booth at PNSY. This option involves the permanent adoption of the process.

This option requires a change in raw materials; however, no new equipment is required. Booth operators will need to be instructed in the use of the new chemicals. Savings will be incurred in decreased downtime for the paint spray booth, decreased time for operator maintenance of the booth, and less wear and tear on the booth from cleaning.

Option 4 - Paint Sludge Dewatering

The paint spray booth generates a paint sludge that is disposed of as waste during routine maintenance. This paint sludge is composed of a high percentage of water. If this water can be extracted from the paint sludge, and recycled to the booth, the volume of waste that is disposed of can be decreased.

The paint sludge can be dewatered mechanically using a bag filter, roll bed filter, filter press, or hydrocyclones. The quantity of sludge generated in the paint booth makes the hydrocyclone the most economical method of dewatering.

Option 5 - High-Volume Low-Pressure Spray Painting

The current equipment used for spray painting in building 990 is the common compressed air type. Testing during various studies at other facilities have shown that this type of spray painting has a relatively low transfer efficiency. The transfer efficiency is the amount of the coating, which is applied to the surface, divided by the amount of coating, which is sprayed from the gun. It is usually expressed as a percentage.

A new paint spraying technique, which may be applicable to these operations is the high-volume low-pressure (HVLP) method. The transfer efficiency of HVLP is in the range of 65% to 90%. Compressed air equipment typically provides a 25% transfer efficiency. Other methods of spray painting such as airless, air assisted airless, and electrostatic spray painting have transfer efficiencies ranging from 35% to 65%. Of these, electrostatic spray painting has the highest transfer efficiency. However, electrostatic spay painting will cost significantly more to retrofit than HVLP and therefore is not considered as attractive as HVLP for the PNSY.

The equipment needed to retrofit a HVLP system includes a regulator/filter assembly, air hose, control valve, quick disconnect, and HVLP spray gun. The existing air compressors are expected to be adequate for the application of HVLP painting and will not need to be replaced.

Option 6 - Operator Training and Awareness

Paint and paint wastes comprise the second largest hazardous waste stream generated at PNSY. A program that encourages operator involvement and responsibility can reduce the amount of waste paint by controlling the amount of paint overspray, the amount of unused paint left in the can, and the amount of paint that is unusable due to partial solidification prior to use.

Option 6 relates strictly to personnel/procedural related changes. No new equipment or materials are necessary. Training can be done in-house and on-site by existing Naval personnel who are knowledgeable in the areas of waste minimization, general painting operations, and booth operating procedures. An application of Option 6 base-wide can reduce wastes generated in every painting department.

Option 7 - Recovery of Concentrated Citric Acid Solution

This option is a batch process for the recovery of spent concentrated citric acid/TEA solution from derusting operations (Figure 1). This system employs equipment that is used for similar processes but has not been specifically applied to citric acid derusting wastewaters.

The proposed recovery process includes three main operations: 1) oil and grease (O&G) removal, 2) suspended solids removal, and 3) dissolved metal removal. The recommended equipment for O&G removal is a device which is specifically designed for removal of oils from hipboard bilge waters. This unit employs enhanced gravity separation and coalescer beds of polypropylene. It has a modular design which includes all necessary pumps and controls.

The proposed device for suspended solids is a floating ceramic media backwash filter. An upflow service, downflow backwash design is recommended. It is capable of removing suspended solids with a size greater than 5 microns. The backwash cycle can be automatically initiated with a pressure differential switch. The backwash (1-5% of treated volume) from the filter could be recycled to the storage tank or drummed for disposal.

The discharge from the filter would be collected in the recovery tank. A level control would sense when a sufficient volume has been collected and would shut off the feed pump on the oil removal system. The electrodialysis (ED) unit would then be energized. The proposed ED unit is a technology specifically designed for removal of cations (e.g., iron, lead, trivalent chromium, cadmium) from acid baths. It is most often used for bath maintenance of hard chrome plating solutions, but has been successfully tested in the laboratory for citric acid/TEA solution maintenance. This technology consists of an electrochemical cell (cylindrical unit placed into recovery tank) and a cathode tank. The cell is designed with a set of anodes which contact the acid solution, a cation-specific membrane, and a cathode which is located within the membrane compartment.

RANKING OF OPTIONS

The assessment phase includes data collection, selection of target areas, data review, and options generation and screening. Table 1 lists the nine individual wastestreams that were considered during the assessment, and includes the building or location where they are generated and the associated industrial process. Table 1 also lists some key data for each wastestream including: the volume generated on an annual basis, the hazardous characteristics of the waste, the annual disposal cost, the raw material costs for input materials that are considered partially recoverable, the waste minimization options that were

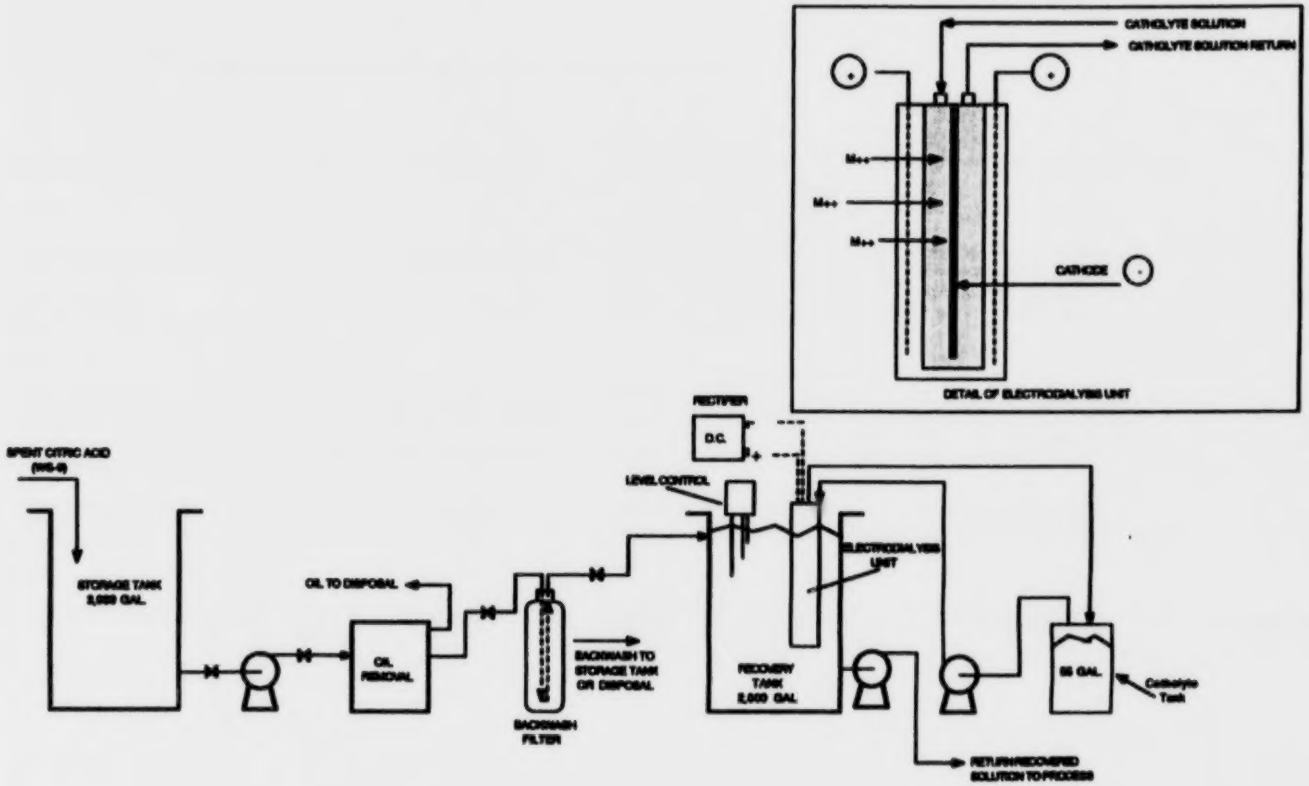

FIGURE 1. RECOVERY PROCESS FOR CONCENTRATED CITRIC ACID WASTEWATERS

LOCATION/PROCESS/WASTE STREAM	VOLUME GPY	CHARACTERISTICS	DISPOSAL COST, $/YR	RAW MAT. COSTS, $/YR*	WM OPTIONS	WM OPTION SCREENING SCORE
BUILDING 996						
ALUMINUM CLEANING						
SPENT KRC-7X (WS-1)	7,040	LOW pH	$14,010	$48,120	DRAGOUT REDUCTION AND BATH MAINTENANCE (OP-1)	383
SPENT RINSE WATER (WS-2)	45,760	LOW pH	$70,928	$0	TWO STAGE RINSE (OP-2)	386
SPRAY PAINTING OF ALUMINUM						
PAINT SLUDGE (WS-3)	2,000	TOXIC METALS/IGNITABLE	$3,760	$2,800	BOOTH GUARD (OP-3), SLUDGE DEWATERING (OP-4), AND HVLP SPRAY PAINTING (OP-5)	308, 288 339
USED PAINT THINNER (WS-4)	520	TM/IGNIT/TOXIC ORGANICS	$976	$1,680	AWARENESS AND TRAINING (OP-6)	393
UNUSED PAINT (WS-5)	UNK.	TOXIC METALS/IGNITABLE	$350,000**	UNK.	AWARENESS AND TRAINING (OP-6)	393
BUILDING 1555						
SPRAY PAINTING OF STEEL						
PAINT SLUDGE (WS-6)	3,600	TOXIC METALS/IGNITABLE	$6,768	$2,800	BOOTH GUARD (OP-3), SLUDGE DEWATERING (OP-4), AND HVLP SPRAY PAINTING (OP-5)	308, 288 339
USED PAINT THINNER (WS-7)	520	TM/IGNIT/TOXIC ORGANICS	$976	$1,680	AWARENESS AND TRAINING (OP-6)	393
UNUSED PAINT (WS-8)	UNK.	TOXIC METALS/IGNITABLE	INCLUDED ABOVE	UNK.	AWARENESS AND TRAINING (OP-6)	393
DRYDOCKS						
CITRIC ACID DERUSTING						
CONC. CITRIC ACID/TEA (WS-9)	16,000	LOW pH, TOXIC METALS	$45,750	$26,984	ELECTRODIALYSIS RECOVERY SYSTEM (OP-7)	

*RAW MATERIAL COSTS ARE ONLY GIVEN FOR MATERIALS CONSIDERED TO BE AT LEAST PARTIALLY RECOVERABLE.
**INCLUDES ENTIRE SHIPYARD.

TABLE 1. SUMMARY OF WM ASSESSMENT PHASE

considered in the screening step, and the scores from the WM option screening process.

CONCLUSIONS AND RECOMMENDATIONS

The technical and economic results of the feasibility analysis phase are summarized in Table 2. This table indicates for each option, the total capital investment, the net operating cost savings and the payback period (total capital investment/net operating cost savings).

The relative comparison used in this study indicates that the best options appear to be: Option 6 - Awareness and Training, Option 1 - KRC-7X Dragout Reduction and Bath Maintenance and Option 2 - Two Stage Rinsing. The implementation of these three options would cost $39,560 and result in and annual savings of $158,680. The implementation of all seven options would cost $144,982 and result in an annual savings of $246,180.

Option 7 appears to be a viable candidate for research, development, and demonstration. This option involves the implementation of equipment for the recovery of citric acid/TEA solution.

It is important to note that the PNSY is not a commercial production facility, but rather a government facility that is operated for revitalizing and repairing ships. As such, the payback period of the WM options evaluated may be different than for commercial operations. Also, other WM options that were not evaluated in this study may be applicable to commercial operations.

FORT RILEY, KANSAS

Fort Riley is a permanent U.S. Army Forces Command (FORSCOM) Installation that provides support and training facilities for the 1st Infantry Division (Mechanized), Non-Divisional Units, and tenant activities.

Among the numerous activities present at Fort Riley is the maintenance of the 1st Infantry Division's vehicles (trucks, tanks, armored personnel carriers, etc.). Routine maintenance is conducted at various motor pools. Equipment repairing and rebuilding is carried out by a contractor located on-base. Most of the hazardous waste generated at Fort Riley is generated from these repairing and rebuilding operations. Two operations were identified which account for a major portion of the hazardous waste generated. These include battery service and repair, and

LOCATION, PROCESS & WASTESTREAM (WS)	WASTE MINIMIZATION OPTIONS	NATURE OF WM OPTION	CAPITAL INVESTMENT ($)	NET OP. COST SAVINGS ($/YR*)	PAYBACK PERIOD (YR*)
BUILDING 990					
ALUMINUM CLEANING					
SPENT KRC-7X (WS-1)	BATH MAINTENANCE (OP-1)	EQUIPMENT	$12,220	$44,190	0.3
SPENT RINSE WATER (WS-2)	TWO STAGE RINSE (OP-2)	EQUIPMENT	$3,116	$34,592	0.1
SPRAY PAINTING OF ALUMINUM					
PAINT SLUDGE (WS-3)	BOOTH GUARD (OP-3)	MATERIALS	$12,190	$10,890	1.4
	PAINT SLUDGE DEWATER. (OP-4)	EQUIPMENT	$9,550	$7,720	1.2
	HVLP SPRAY PAINTING (OP-5)	EQUIPMENT	$7,630	$8,170	
USED PAINT THINNER (WS-4)	AWARENESS & TRAINING (OP-6)	PERSONNEL/PROCED.	$24,226	$79,900*	0.3
UNUSED PAINT (WS-5)	AWARENESS & TRAINING (OP-6)	PERSONNEL/PROCED.			
BUILDING 1028					
SPRAY PAINTING OF STEEL					
PAINT SLUDGE (WS-6)	BOOTH GUARD (OP-3)	MATERIALS	SEE WS-3	SEE WS-3**	SEE WS-3**
	PAINT SLUDGE DEWATER. (OP-4)	EQUIPMENT	SEE WS-3	SEE WS-3**	SEE WS-3**
	HVLP SPRAY PAINTING (OP-5)	EQUIPMENT	SEE WS-3	SEE WS-3**	
USED PAINT THINNER (WS-7)	AWARENESS & TRAINING (OP-6)	PERSONNEL/PROCED.	SEE WS-4	SEE WS-4**	SEE WS-4**
UNUSED PAINT (WS-8)	AWARENESS & TRAINING (OP-6)	PERSONNEL/PROCED.	SEE WS-4	SEE WS-4**	SEE WS-4**
DRYDOCKS					
CITRIC ACID DERUSTING					
CONC. CITRIC/TEA (WS-9)	ED RECOVERY SYSTEM (OP-7)	EQUIPMENT	$76,050	$60,720	1.3

*INCLUDES ENTIRE SHIPYARD.
**OPTIONS 3 AND 4 INCLUDE BOTH BLGD. 990 AND 1028.

TABLE 2. SUMMARY OF WM FEASIBILITY ANALYSIS PHASE

automotive subassembly rebuilding shop. Battery service repair generates waste acid (32% to 37% sulfuric acid) which is currently collected in drums and shipped off-site for disposal as hazardous waste. This acid contains trace concentrations of lead and cadmium. The automotive subassembly rebuilding shop contains a parts washer which cleans parts with hot aqueous alkaline detergent. This waste, currently being reclassified as RCRA, D007 and D008, is drained to an on-site waste evaporation pond.

WASTE MINIMIZATION OPTIONS

Waste Battery Acid

The Versar team proposed that the waste acid be gathered in a holding tank, filtered to remove any particulates, and adjusted in concentration to 37 percent sulfuric acid (using 60° Baume commercial sulfuric acid) as needed for reuse in reconditioned or new batteries. To prevent buildup of dissolved metal impurities in this recycling system, part of the acid would be purged from the system. This assessment assumes that 25 percent of the acid would be purged and 75 percent reused. The acid being purged would be neutralized, treated to remove trace heavy metal, and disposed of onsite to a lagoon as a nonhazardous waste.

Automotive Parts Washer Wastewater

The dirty aqueous alkaline detergent solution that results from cleaning automotive parts contains trace concentrations of lead, chromium, and cadmium at a pH >12 as well as the oils, grease, and dirt removed from the automotive parts. Currently, the solution is drained to an onsite nonhazardous waste evaporation pond. This waste, heretofore regarded as nonhazardous, is being reclassified as a RCRA hazardous waste because of it's characteristics (D007, D008). When reclassified, it will have to be disposed of as a hazardous waste through DRMO. The Versar team proposed option for this stream involves using equipment external to the automotive parts washer. The proposed process would include emulsion breaking to cause emulsified oils to float, removal of de-emulsified oils and other tramp oils and grease by skimming, filtration to remove particulates (in-line cartridge filter, and addition of fresh alkaline detergent as necessary. The cleaned washwater would then be recirculated to the automotive parts cleaner. Buildup of impurities in the recycled washwater would be prevented by purging 25 percent of the used alkaline detergent and recycling 75 percent. The material being purged would be neutralized with an appropriate amount of waste battery acid, treated to remove precipitated trace heavy metal impurities, and disposed of as a nonhazardous waste.

Results of Waste Reduction Audit

The results of the waste reduction audit are summarized in Tables 3 and 4.

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Results of Waste Reduction Audit

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TABLE 3. SUMMARY OF FORT RILEY, KANSAS, BUILDING 8100 WASTE REDUCTION ASSESSMENT

Source of Hazardous Waste Stream	Waste	Current Disposal Cost	Current Raw Material Cost
Battery repair shop	7,200 gal/year D002, D006, D008*	$27,900/yr	$11,530/year
Automotive parts washing	29,000 gal/year D007, D008**	$112,000/yr***	<$100/yr

*D002 - Corrosive waste (<2 pH >12).
D006 - Cadmium-containing RCRA characteristic hazardous waste.
D008 - Lead-containing RCRA characteristic hazardous waste.

**D007 - Chromium-containing RCRA characteristic hazardous waste.

***Although this waste currently is drained to an onsite evaporation pond, if it were disposed of as a RCRA hazardous waste via DRMO at the same cost per gallon as the waste battery acid, the costs and savings would be as indicated.

TABLE 4. SUMMARY OF ECONOMIC ANALYSIS FOR PROPOSED WASTE MINIMIZATION OPTIONS AT FORT RILEY, KANSAS, BUILDING 8100

Source of Hazardous Waste Stream	Waste Reduction Option	Capital Investment	Operating Cost Saving, $/year	Payback year
Battery repair shop	Recycle of restrengthened battery acid	$15,200	$36,000	0.42
Automotive parts washing	Recycle of purified alkaline detergent solution	$19,800	$107,100	0.18

SECURING SAFE SUBSTITUTES: POLICY MEASURES TO PROMOTE SAFE CHEMICAL SUBSTITUTES

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INTRODUCTION

Safe substitutes are non-toxic or less toxic chemicals or alternative practices that reduce or eliminate the use of toxic chemicals. Substitution of safer chemicals and alternative practices for the toxic chemicals now used extensively to provide most goods and services would dramatically reduce hazardous waste generation, reduce toxic air and water pollution, reduce human exposure to toxic chemicals in the workplace and in the home, and reduce subtle damage to the ecosystem. Furthermore, as many companies have already discovered, reducing the use of toxic chemicals saves money spent on environmental controls, penalties, cleanup costs, and worker health care.

The coming of safe substitutes can proceed in a haphazard, market-driven and piecemeal regulatory approach, or there can be a conscious, comprehensive program for bringing about a non-toxic 21st Century. This paper summarizes the preliminary policy recommendations from a two-year study of the potential for dramatically reducing the use of toxic chemicals. That study will be published in book form in 1991.

Since the use of toxic chemicals pervades the workplace, the home, and the farm, policy measures to promote safe substitutes must address each of these areas. To this end, the study first evaluated existing statutes and regulations that directly and indirectly impact toxic chemical use. In addition, the study evaluated various state and local requirements now being implemented that go beyond federal laws by requiring labeling of products, by banning certain products, or by making toxics use reduction an explicit policy. Last, but not least, the study addressed the use of various measures for increasing the interest and awareness of consumers and the public at large in promoting safe substitutes.

STRATEGIES TO PROMOTE SAFE SUBSTITUTES

There are five areas in which recommendations have been developed for the promotion of safe substitutes through both government and consumer and citizen strategies. These are:

- National toxic chemical policy
- Testing and regulation of toxic chemicals
- Agriculture policy
- Industry and toxics use reduction
- Consumer products

NATIONAL TOXIC CHEMICAL POLICY

The Toxic Substances Control Act ("TSCA"), enacted in 1976, is "the sleeping giant" of federal environmental legislation: it has the potential to accomplish much positive change if it were reformulated and given proper backing. At present, the patchwork of toxic chemical regulations, under various environmental, consumer, and worker protection laws, is inconsistent, slapdash, and simply not effective in controlling toxics production, use and disposal. Furthermore, there is no clear goal behind TSCA to reduce the use of toxic chemicals and to promote safe substitutes.

The following recommendations are made:

- It should be the policy of the federal government to reduce the production and use of toxic chemicals in a coordinated fashion throughout the fields of industry, agriculture, and consumer products.
- It should also be the policy of the federal government to encourage the use of safe substitutes in an affirmative manner through research, technology transfer, public education, and financial incentives.

TESTING AND REGULATION OF TOXIC CHEMICALS

The Toxic Substances Control Act should be the vehicle for the comprehensive prioritization and regulation of toxic chemicals from cradle to grave. It should be coordinating risk assessment of chemicals through all routes of exposure and deciding whether chemicals should be restricted in their use or production. TSCA should also guide the regulation of toxic chemicals in specific regulatory programs, decide when more restrictive measures are needed, and affirmatively promote safe substitutes.

Of the thousands of chemicals in use today, how do we decide which ones should be priorities for substitution? Where do we stand in our ability to answer that question? And how do we go about eliminating those priority chemicals? Unfortunately, the situation is not encouraging:

- Worldwide, some 70,000 chemicals are in use with between 500 and 1,000 new ones added each year. EPA has compiled a list of more than 48,000 chemicals in the U.S. existing chemical inventory. While only a small percentage are likely to be harmful to people and the environment, no information is available on the toxic effects of nearly 80% of those chemicals.

- Fewer than one-tenth of existing chemicals have been tested for long-term effects, such as cancer or reproductive effects, and virtually no evaluation has been performed of the cummulative effects on the ecosystem.

- In the 14-year history of TSCA only about 10% of existing chemicals have been reviewed by the Interagency Testing Committee to determine if more testing is needed.

- There is no requirement for new chemicals to be tested before introduction into the marketplace under TSCA.

Ideally, criteria for prioritizing chemicals for substitution would take into account toxicity to humans and the environment, including acute and chronic effects, and would take into account potential for exposure from production, through use, to disposal. Much of the information needed to fully assess chemical impacts in this manner simply does not exist, nor is any agency seriously looking at the full "life-cycle" impacts of chemicals.

There has also been paralysis by analysis. The scientific issues are very difficult, and EPA has set a difficult burden for itself in selecting chemicals for testing and regulation.

Although outright product or ingredient bans are politically difficult, many of the major gains in protection of health and environment from the effects of toxic chemicals have come this way. These include, for example, reductions in lead exposure from the phase-out of leaded gasoline, reductions in PCB exposures following the Congressionally-mandated phase-out, reductions in asbestos exposure, and reductions in chlorofluorocarbon use.

Statutory authorities that can restrict chemicals have been used sparingly, largely because of the heavy burden imposed upon the government to justify any interference with the chemical marketplace. Under most existing statutes agencies bear the burden in demonstrating that chemical products pose "unreasonable risks" and are often directed to balance risks with the economic benefits of the chemicals.

Should chemicals be treated as innocent until proven guilty? In other words, should they be produced, marketed, used, and disposed of until a government agency musters enough evidence that they should be restricted? How much evidence is enough, and in weighing the evidence, where should the burden of scientific uncertainty fall? These are some of the critical questions that must be answered in revamping the system of chemical testing and regulation.

Many now believe that it is important to move forward, even with imperfect knowledge. For instance, the Organization for

Economic Cooperation and Development Chemicals Group has begun to set priorities for requiring testing of high-volume chemicals without laborious rulemaking proceedings. The Swedish government has gone even further by initiating the "sunset chemicals" program to select high-priority chemicals to phase out production and use.

Despite the lack of information and the slowness of testing programs, it should be possible to at least develop a rough priority scheme for chemicals that should be candidates for substitution. Using such a priority scheme, we can at least implement positive non-regulatory measures to encourage safe substitutes without getting bogged down in an impossibly detailed analysis.

The following are general recommendations in this area:

- The Toxic Substances Control Act should be revamped so as to become the overarching statute for testing, risk assessment, regulation, and standard setting for toxic chemicals throughout federal regulatory programs that have responsibility for protecting the public and the environment from exposure to toxic chemicals.
- The regulation of and standard setting for toxic chemical exposures should be integrated and made consistent throughout all uses of toxic chemicals and all routes of exposure. Cummulative exposures and synergistic effects should be considered in chemical risk assessment and standard setting.
- For existing chemicals, priority chemicals should be identified and the burden of proof should shift to the manufacturers and users to demonstrate their safety for continued use.
- For new chemicals, testing should be mandatory under TSCA, and manufacturers should have the burden of demonstrating safety before introduction of the chemicals into the marketplace.
- The patent life for chemicals should be extended so that thorough testing prior to introduction of new chemicals into the marketplace is not penalized.
- EPA and other nations, with coordination by international organizations, should implement a range of policies to phase out the production and use of priority (sunset) chemicals.
- Policy measures for the phase-out of priority chemicals should include bans, restrictions on certain uses, financial incentives, research and development, and public eduction.

AGRICULTURE POLICY

Current American agricultural practices, centering on large-scale use of pesticides and synthetic fertilizers, are not physically, economically, or politically sustainable. Since 1945 the use of synthetic pesticides in the United States has grown 33-fold, but the percentage of crop losses due to pests, including insects and weeds has not decreased. Losses due to insects have nearly doubled since 1945, but those losses have been offset by technological changes, such as new plant varieties and increased use of fertilizers.

The U.S. now spends about $4.1 billion on agricultural pesticides annually. These costs do not include the health and environmental costs of massive pestide use, however. In addition to these unaccounted for costs, the efficacy of pesticides is being eroded as pest resistance grows.

Today, alternative agriculture (also called "low-input, sustainable agriculture" or "organic farming") is on the rise. The number of acres of land cultivated by organic practices is growing by 15% per year. Consumers are demanding reduced use of pesticides because of concerns over residues of cancer-causing chemicals in food and are willing to pay a premium for "safe" food.

Three countries, Denmark, Sweden and the Netherlands, have recently mandated a 50 percent reduction in the use of agricultural pesticides: Sweden in five years, Denmark by 1997, and the Netherlands within 10 years. Is such a reduction possible in the United States and at what cost to farmers and consumers?

According to a recent study at Cornell University, pesticide use can be reduced by at least 50% in the United States through a combination of relatively simple alternatives with no loss in yields and only slight increases in retail food costs. The study estimated that reducing pesticide use by 50 percent would cost approximately $1 billion. If there were no decline in crop yields, the total price increase to the consumer would be only about 1.5%. The increased costs of alternative pest control methods would be offset by reduction in pesticide costs alone, without even taking into account the indirect costs of pesticide use, such as environmental damage and human health problems.

Aside from the federal government role in regulating the use of pesticides, federal agricultural policy also plays a large role in pesticide use. In this case, farmers themselves could effect dramatic reductions in pesticide use if the federal government would, first, just get out of the way, and, second, give them some encouragement.

Obstacles to reducing pesticide use include:

- overproduction of crops with attendant pesticide use, supported by the farm subsidy program, which also depresses farm product prices;
- the commodity program, which discourages farmers from using simple alternatives to pesticides, such as crop rotations;
- crop insurance policies, which often require the use of pesticides at certain levels;
- simple resistance to change by farmers who have been using pesticides for years; and
- lack of emphasis on alternative practices in agricultural extension and education programs.

Implementing pesticide reductions through farm policy will take longer than simple pesticide bans and phase-outs. It may be too little, too late, to save ground water and protect the safety of food. But the two methods of pesticide reduction can go hand in hand. There are some pesticides that should be taken off the market immediately, and for which immediate bans will find wide support.

But because of the scientific uncertainties and the political clout of pesticide manufacturers, reductions in use of most pesticides can best be brought about by a concerted effort to remove obstacles to alternative practices and to greatly increase educational programs for farmers.

The following are general recommendations in this area:

- Farm subsidy programs should be revised to remove obstacles to safe substitutes, such as crop rotation.
- Crop insurance policies should be regulated, if necessary, to permit the use of alternatives to pesticides without sacrificing coverage.
- The Federal Insecticide Fungicide and Rodenticide Act ("FIFRA") should be amended to explicitly adopt the "Delaney" approach to pesticide residues in food. The only "de minimis" levels of pesticides that cause cancer or reproductive hazards in animals that should be permitted are those in background concentrations.
- FIFRA should also be amended to remove the requirement that EPA must purchase stocks of banned pesticides. Alternatively, there should be a tax levied on all pesticides to create a large fund for purchase of stocks of banned pesticides and for other purposes.
- Increased funding should be made available for research and education on alternative farming practices that reduce or eliminate pesticide use. The National Research Council recommended that funding be increased tenfold from $4 million to $40 million.

INDUSTRY AND TOXICS USE REDUCTION

Virtually every industry uses some toxic chemicals, even if the products ultimately produced and sold are innocuous themselves. The Toxics Release Inventory, based on an EPA survey of 1987 releases of toxic chemicals into air, water, and soil by manufacturers, found that 22.5 billion pounds of toxic chemicals each year are released to the environment or transferred from the plant site for disposal: 2.7 billion pounds to air; 9.6 billion pounds to surface water; 5.7 billion pounds to soil and underground injection; and 4.5 billion pounds to off-site disposal. The chemical industry generates by far the greatest amount with 12.1 billion pounds released and transferred.

Although there are some notable exceptions, most companies have simply not considered safe substitutes for the toxic chemicals they use or produce. The Toxics Release Inventory, for instance found that only about 6% of the respondents stated that they had substituted inputs or reformulated products to reduce environmental releases of toxic chemicals.

Why are safe substitutes not being implemented rapidly by industry? Because we have focused on pollution control in this country for 20 years. Our environmental programs have rarely challenged the use of toxic chemicals or the production of toxic products, since the focus has been on controlling pollutants and treating wastes.

There are several disincentives to making a wholehearted search for safe substitutes in industry. Among those disincentives:

- Safe substitutes are the most complex waste reduction strategy, since they require intimate knowledge of chemical processes, creative engineering, and potentially expensive equipment modifications.
- Chemical product manufacturers and users are reluctant to try new products when the ones in long use perform the manufacturing functions satisfactorily.
- Product specifications, including military specifications, sometimes force manufacturers to use toxic chemicals in their manufacturing operations.
- Chemical-user industries, such as the electronics industry, are in a sense, "captured and dominated" by the chemical producers, since the users do not usually have the capability to develop alternatives themselves. Small users rarely have the clout to demand safe substitutes from large chemical producers.
- Engineers are not taught to consider reduction in use of toxic chemicals in designing processes, and once capital investments are made, redesign cannot be considered for several years.

What government initiatives can help overcome these obstacles? The new Massachusetts Toxics Use Reduction ("TUR") Act is a promising initiative for moving industry toward safe substitutes. The TUR legislation is primarily a mandatory planning process to force companies using toxic chemicals to plan for a reduction in use. The Act includes oversight from the state environmental regulatory agency and some public access to planning information as well as training and certification for TUR planners.

Industry may resist toxics use reduction strategies because of the seeming intrusion into internal business and engineering decisions. The Massachusetts legislation tempers this intrusion by focussing on flexible policies, such as planning, technical assistance, and training.

The following are recommendations in this area:

- Toxics use reduction should become a major goal of federal and state waste reduction programs, relying primarily on technical assistance and planning requirements as does the Massachusetts Act.
- Permits for air and water pollution and hazardous waste management should be coordinated, so that transfers of toxic chemicals from one environmental compartment to another do not occur and so that overall reductions in toxic chemical releases can be achieved through the permit process.
- Incentives should be provided to promote the use of safe substitutes. EPA should give clear signals about priorities for substitution and use research and development grants, information transfer, and, if necessary, subsidies, to encourage use of substitutes.

CONSUMER PRODUCTS

Many of the products we use in our homes or purchase as consumers contain chemicals that can cause illness or injury. Products that are not toxic in and of themselves may result in secondary problems due to the processes used to produce them or the impacts caused by their disposal.

The following illustrate the scope of the problem:

- 5-10 million household poisonings are reported every year involving a wide variety of chemicals.
- Air samples in typical buildings include 100-200 volatile organic chemicals, including suspected carcinogens, from sources such as cleansers, disinfectants, paints, carpets, and wood products.
- Formaldehyde is found in thousands of products, including permanent pressed clothing, paper products, cosmetics, plywood, paneling, spray starch, cleaners, and air fresheners. Its presence in indoor air has been linked to respiratory ailments, allergic reactions, and in one study, to cancer of the nose and pharynx.
- Nearly 90% of American households use some type of pesticides, including termite and roach sprays, flea bombs, pesticide strips, flea powder for pets, garden insecticides, and lawn chemicals.
- Disposal of toxic household products causes injuries to waste management workers, contamination of ground water from landfilling, or air pollution from incineration.

The feasibility of safe substitutes has been better established in the area of consumer products than anywhere else. Until the Chemical Age that followed World War II, most homes were constructed with non-toxic building materials, and most householders used a few simple substances to keep the house clean, odor-free, and pest-free. Current alternatives to the usual toxic materials of a house and of household products are not only available, but can be more economical.

Given adequate information, consumers can speak with a loud voice for safe substitutes. The primary vehicle for consumer education about product choices is the product label. Product labeling can be either positive or negative. Positive labeling is exemplified by "green labeling" or "environmental labeling" that has taken hold in Western Europe and recently in Canada and Japan. Negative labeling is most often seen as hazard labeling or simply a listing of product ingredients, so that consumers can determine for themselves if they believe the product to be too hazardous for their use.

Green Labeling

The purpose of "green labeling" or "environmental labeling" is to give consumers an easy way of recognizing products that create relatively few health or environmental impacts. Such advertising claims have already become the hot new marketing strategy of the Earth-Day conscious 1990's. Ideally, in such a labeling scheme an independent body would award products with the right to use an easily recognizable environmental logo after a careful assessment of their life-cycle impacts including the impacts of the product itself, the packaging, and the process that produces it (the 3 P's). Programs that have been set up in other countries are voluntary for manufacturers and depend upon consumer interest in "environmentally friendly" products to create the incentive for manufacturers to produce such products and seek the label.

West Germany and Canada both have comprehensive labeling programs. Could such a program work in the U.S.? Interest in this country is only beginning, and such issues as who is to do the labeling, how criteria for labeling are to be established, and what types of products should be considered are still to be answered.

Hazard Labeling

Hazard labeling informs the consumer of the identity of toxic chemicals present in the product or uses simple hazard statements. Government standards are set for the contents of hazard labels under federal and state laws. How much information about the hazards of products should consumers be given on labels, and what form should that information be in? Is there such thing as too much information, and who should decide what is needed?

The recently enacted California Proposition 65, goes beyond typical labeling requirements to warn consumers of products that contain carcinogens, mutagens, and teratogens, even in levels that may be considered "safe" by federal regulatory agencies. Although there have been problems with the adequacy of the warnings required by a sometimes unwilling state bureaucracy, Proposition 65 has had an impact. Companies have been reformulating products that contain the listed chemicals to avoid potential consumer rejection.

There is a need for expanded labeling for products containing toxic chemicals, including expanded listings of hazards and more complete listings of product ingredients. Support for expanded labeling stems from the limited information currently required for product labels. Such support also stems from the desire to provide the public with personal autonomy when it comes to decisions about personal health and product hazards, rather than having the science bureaucracy make all of the decisions for them about "acceptable" risks.

Community and worker right-to-know laws, which are another aspect of providing chemical hazard information, are also having an impact on toxic chemical use. The Toxics Release Inventory, discussed above, provided communities for the first time comprehensive information on the toxic chemicals released into the air and water. As a result, local toxic use reduction campaigns have sprung up, and companies interested in their images have voluntarily initiated programs for reducing toxic chemical use. Worker right-to-know programs have also had an impact in the workplace, as replacement of toxic chemicals has become an item in labor negotiations.

The public has a right to take control over their exposure to toxic chemicals, as happened very quickly once information about the pesticide Alar was made widely available. The Alar public information campaign demonstrated that government agencies do not have a monopoly on decision-making about acceptable risks. With better information, the marketplace can react more quickly than cumbersome government regulations.

The following are recommendations in this area:

- A national environmental labeling program should be created to give consumers clear signals about the most environmentally acceptable products, including those that do not contain or are not derived from toxic chemicals.
- The nationwide labeling program should be created by federal legislation but administered by an independent non-government organization for the sake of credibility.
    - The national labeling program should preempt other environmental claims on product labels to preserve the credibility of environmental labeling.
    - The program should be voluntary, and high standards should be set for receipt of the label in order to maintain the program's credibility in the eyes of consumers.
    - The criteria for labeling should assess the life-cycle impacts of products as much as is necessary and practicable.
    - Some entire classes of products should not be considered for labeling, since some classes as a whole are too polluting.
    - Monitoring of producers who receive the logo is very important to insure that products continue to meet labeling standards.
- Hazard labeling should be expanded to include warnings on products that contain chemicals that have been shown to cause cancer or reproductive damage in animals.
- Public education programs should target all segments of the population concerning the hazards of household toxics, proper disposal methods and, most importantly, safe substitutes for those toxic products.

CONCLUSION

Ultimately, a mix of strategies will be necessary to hasten the use of safe substitutes. The most important step is for governments at all levels to begin to take a leadership role, and for consumers and the general public, eager to "do the right thing" for the environment, to be given accurate, objective information on the products they buy and the releases of toxic chemicals in their communities.

OPEN-GRADIENT MAGNETIC SEPARATION FOR PHYSICAL COAL CLEANING: RESULTS FOR PITTSBURGH #8 AND UPPER FREEPORT COALS

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ABSTRACT

Open-Gradient Magnetic Separation (OGMS) using superconducting quadrupole magnets offers a novel beneficiation techology for removing pyritic sulfur from pulverized dry coal. It is estimated to have a power demand 75% lower than techniques using conventional electromagnets, while achieving higher separation forces. Additionally, the system operates in a continuous mode and uses no chemicals. Because OGMS is specifically applicable to finely ground coal (120-325 mesh), its development could encourage the commercialization of other unconventional coal technologies, such as coal-water slurries, fluidized-bed combustion, and synfuels.

OBJECTIVES OF COAL BENEFICIATION

Deep cleaning of high-sulfur Midwest coals using conventional technologies should reduce total sulfur from 20 to 50% by removing the inorganic sulfur[1]. However, all physical coal-cleaning processes (including open-gradient magnetic separation) are limited by their inability to remove organic sulfur intimately bound to the coal macerals. [2] Inorganic sulfur in coal exists primarily as pyrite crystals (FeS_2) of varying size, with a size distribution that differs from coal to coal.[3] The specific-gravity of the pyrite particles is about 4.9, while that of the coal macerals ranges from 1.7 to 1.3.[4] In current commercial practice, pyrites and other minerals are separated from the coal macerals on the basis of specific gravity differences (e.g., in cyclones) or differences in surface-wetting characteristics (e.g., by froth flotation). Subsequent handling and dewatering of coal slurries produced during processing has proven costly, and this situation is worsened by fine grinding to liberate small pyrite crystals.

The physical basis for open-gradient magnetic separation (OGMS) is that mineral inclusions in the coal are paramagnetic (attracted toward a magnetic field), while organic coal materials are weakly

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diamagnetic (repulsed from a magnetic field). Because these two classes of components are subject to opposing forces when placed in a magnetic field gradient, they can be separated into different streams, such as waste, middlings, and clean product.

SINGLE-PARTICLE MODEL

This program was designed to use a quadrupole magnetic field, because it is capable of producing a very uniform, intense magnetic-field gradient in the central bore, characterized by a high field at the bore wall and a zero field at the center.[5] This conveys certain advantages: 1) a high field gradient is produced and 2) coal and pyrite move in opposite directions. Coal maceral and pyrite speeds and trajectories under the influence of such a magnetic field were modeled.[6] Input parameters included particle diameter, density, magnetic susceptibility, position when entering the magnetic field, field strength, and gas viscosity. The magnitude of the separating force on these two classes of compounds may be compared by noting that the volume susceptibility of pyrite is 19×10^{-6} dimensionless MKS units, while that of diamagnetic coal is -3×10^{-6} dimensionless MKS units.

The predicted maceral and pyrite trajectories are compared in Figure 1 for a 60-Wb/m^3 field. These predictions compare favorably with subsequent experiments run at 53.3 Wb/m^3. From the calculated pyrite and maceral trajectories, it can be seen that even a short bore length should prove adequate for separation. As an example, a 100-µm pyrite crystal starting from the mid-radius of the bore should reach the bore wall within 0.3 s after falling about 0.3 m. Starting from the same position, a 100-µm coal maceral should move in the opposite direction and reach the center of the bore within 1.25 s after falling about 0.5 m.

EXPERIMENTAL APPARATUS

Based on encouraging modeling results, an experimental OGMS facility was constructed at Argonne (Figure 2). Coal is metered into the system through an AccuRate® pulverized-coal screw feeder capable of feeding coal at 0-20 kg/h. Typically, the feed rates average 2.4 kg/h for these experiments. Coal continuously spills into a vertical pipe that permits 6 ft of free-fall before passing through an annulus of 1.25-1.625 in. and entering the high-magnetic-field zone.

The superconducting quadrupole magnet is wound from a niobium alloy and operates at 4 K with liquid helium cooling. Once the magnet has been energized, its electricity consumption is negligible. In a commercial system only the refrigeration power should prove significant, which led to one estimate for a superconducting magnetic-separation process that put the energy savings over conventional magnets at about 75%[6]. The Argonne experiments operates in a costly liquid helium boil-off mode without recirculation to a refrigerator.

The magnet length is 0.68 m, the diameter of the bore open to the coal is 0.064 m, and the maximum field gradient is 53.3 Wb/m^3. Operational problems with air icing on the upper portion of the coils limited the magnetic gradient to a value lower than the 61-Wb/m^3 operation previously achieved. The quadrupole field (Figure 3) exhibits four "separatrix" zones of zero field strength that are analogous to the middle of the bar for a conventional bar magnet. The coal is confined to the zones of maximum field strength by being blocked with four attached rods from passing through the separatrix zones.

After the coal passes through the magnet, it is recovered by three nested concentric pipes of 1.125, 2.0, and 2.5 in. (O.D.) 316 SS tubing with a knife-edge finish. Each of these splitter pipes in turn is connected to its own separate canister containing a vacuum-cleaner bag that could satisfactorily accomodate 500 g of coal. The suction on each individual canister is monitored and is adjustable at a downstream rotometer.

EXPERIMENTS

Two fresh coals, a Pittsburgh Seam #8 and an Upper Freeport, were tested through the separator. For both coals, the magnetic field measured at the bore wall was maintained at a constant maximum value of 16,100 gauss (53.3 Wb/m^3). The experiments ran in a batch mode for approximately 10 min, with a constant vacuum and speed on the AccuRate® feeder. For comparison, the same coals were run through the system the following day without any magnetic field. This made it possible to determine the effect of the vacuum flow through each individual splitter tube.

RESULTS

Table 1 summarizes results for the two coals tested in a single-stage OGMS system. The coals were passed through the separator both with the field on and off. With the field off, the product streams for both coals show a modest concentration of pyrite (7.9-10.1%) and ash (0-9.5%), which the separating force of the magnetic field needed to work against. This was a consequence of the vacuum draw being set somewhat higher than necessary.

Both coals exhibited significant beneficiation of pyrite and ash. Product-stream (center pipe) sulfur was reduced by 29.7% for the Pittsburgh #8 coal, while the Upper Freeport coal showed an improvement of 18.3%. Corresponding ash reductions were 27.8% and 23.0%, respectively.

TABLE 1. OPEN-GRADIENT MAGNETIC SEPARATION OF COAL*

Coal		Magnet Collection (g/min)		Sulfur (%)	Ash (%)
Pittsburgh #8 (28 x 0) PETC	ON	11.53	P	3.24	8.3
		11.84	M	3.93	9.7
		13.30	R	6.30	15.7
		36.36	Total	4.61 Ave	11.5 Ave
	OFF	12.76	P	5.16	11.6
		13.01	M	4.71	12.1
		12.25	R	4.46	11.5
		38.02	Total	4.78 Ave	11.7 Ave
Upper Freeport (27 x 0) PETC	ON	11.33	P	1.78	19.4
		12.90	M	1.84	25.7
		19.63	R	2.64	28.3
		43.86	Total	2.18 Ave	25.2 Ave
	OFF	12.94	P	2.51	28.7
		13.63	M	2.17	26.0
		15.84	R	2.17	23.8
		42.41	Total	2.28 Ave	26.2 Ave

*P# = #Product, M# = #Middling, R# = #Reject, Ave = Average.

CONCLUSIONS

Single-stage coal beneficiation using open-gradient magnetic separation was investigated, and the results demonstrated that OGMS is capable of effecting a respectable reduction of 24% for both sulfur and ash. The coal residence time in the system was short, and the product was dry.

Additionally, because the separation force is proportional to the square of the magnetic-field gradient, even small changes in the gradient can significantly improve performance. Further opportunities to improve OGMS performance should develop in the future when the next generation of quadrupole magnets is constructed. These magnets will be capable of generating gradients as high as 90 Wb/m^3, a 285% increase in magnetic separating force.

ACKNOWLEDGMENTS

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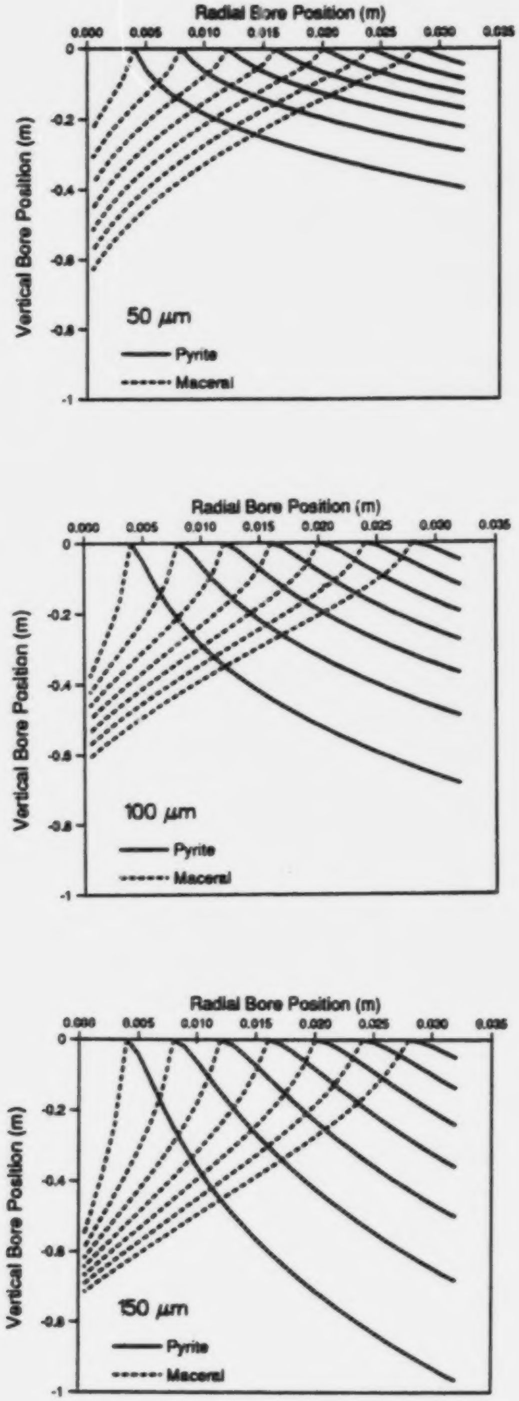

Figure 1. Predicted Trajectories of Pyrite Particles and Coal Macerals in 60-Wb/m^3 magnetic field

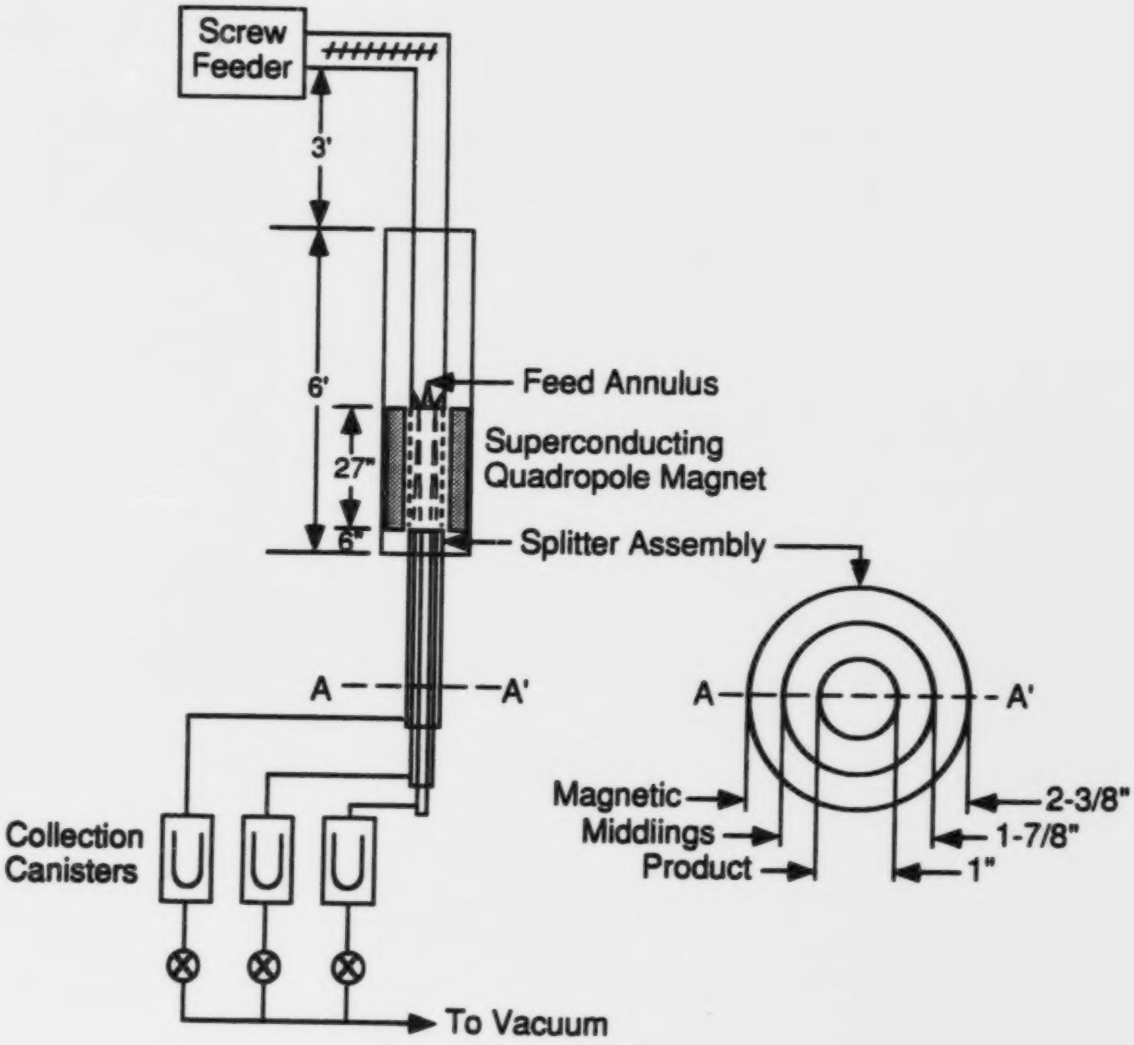

Figure 2. Experimental System for the Superconducting Open-Gradient Magnetic Separation of Coal.

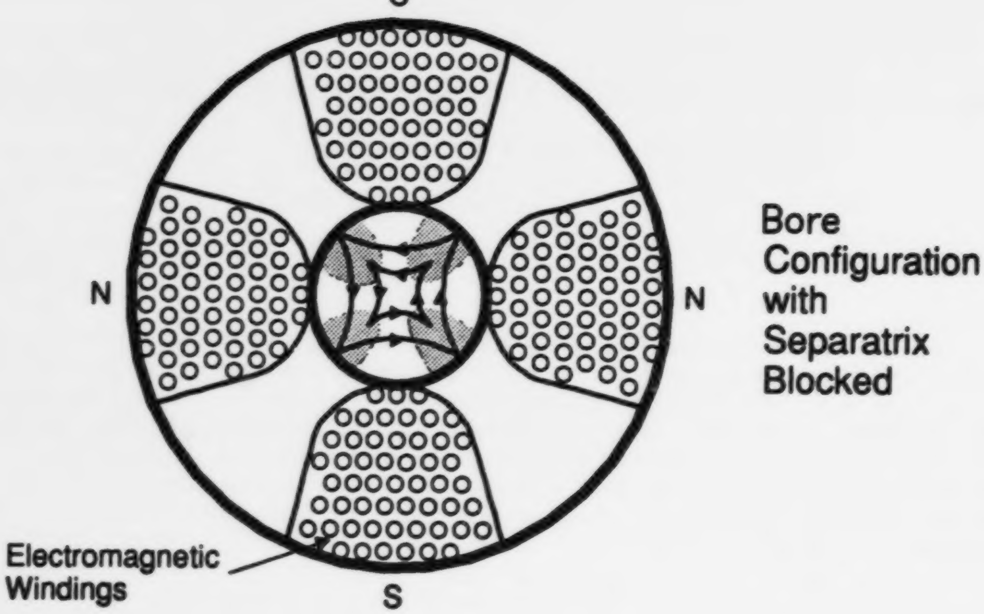

Figure 3. Cross Section of Superconducting Quadrupole Magnet

AN INTERNATIONAL ENVIRONMENTAL CONSCIENCE AND AMERICA'S ROLE

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We in the United States have become very conscious of the state of the environment in recent years and have taken a number of steps to reduce or eliminate the effects of environmental pollutants. At the same time we expect other nations to follow our lead and make environmental protection a priority. As a consequence, Congress has begun to introduce legislation that would impact not only the U.S. but other countries as well. However, these other nations, particularly the developing countries, have other concerns that must be addressed before they can concentrate on the environment. This paper explores some of the factors involved in recently promulgated or introduced legislation.

In 1989, Congress enacted Public Law 101-240, the INTERNATIONAL DEVELOPMENT AND FINANCE ACT OF 1989. Subtitle C-of this law, Environmental Assessments, instructs the United States Director of each multilateral development bank to vote in opposition to any action proposed to be taken by the bank which would have a significant impact on the human environment unless an environmental impact assessment is first provided. Environmental Assessments are made available to the borrowing institution or country, the bank, non-governmental organizations (NGO's) and affected groups. The law further specifies that Director's should work together to develop and propose a procedure for systematic environmental assessment, taking into consideration the Guidelines and Principles for Environmental Impact Assessment promulgated by the United Nations Environmental Programme and other bilateral or multilateral assessment procedures. In addition, PL 101-240 requires interagency and public review of the impact assessments. Congress expected Treasury to develop thorough and adequate guidelines for implementing PL 101-240.

Also during the 101st Congress, S 1089 was introduced. The Bill would amend the National Environmental Policy Act of 1970 (NEPA) to consider the impact of Federal agency actions outside the United States on "global climate change, depletion of the ozone layer, transboundary pollution, biodiversity, and other phenomena of international environmental concern. Furthermore, another bill, S 1045, was introduced to amend NEPA to encourage multilateral development banks to adopt procedures for assessing the environmental impact of development projects funded by those banks.

Under S 1045, the Council of Environmental Quality (CEQ) would be charged with identifying and promulgating internationally accepted criteria for environmental impact assessments in order to facilitate the consideration of environmental impacts in lending decisions. Like PL 101-240, S 1045 would require that the bank directors and the public have access to environmental impact assessments at least 120 days prior to a U.S. vote to support a bank loan. The bill seeks to secure an assessment for public scrutiny that contains relevant environmental information without disclosing unnecessary confidential details.

There is little disagreement that the U.S. has important domestic objectives that cannot be achieved without cooperation from other nations. Yet a number of questions can be raised. Is America in any position to expect foreign countries to abide by the mandate of NEPA and its assessment process when its own government agencies have not always taken NEPA seriously until the courts held them in strict compliance? Is the U.S. exporting its litigious culture with the enactment of this legislation? Is this the best utilization of U.S. expertise and knowledge? Should the U.S. do a better job of transferring its knowledge of environmental science (fate, transport and effects) and environmental engineering? Many questions need to be answered before any additional legislation is passed.

NEPA is the basic national charter by which the United States protects the environment. It establishes policy, sets goals and provides means for carrying out that policy. It contains "action-forcing" provisions to make sure that federal agencies act according to the letter and spirit of the act. The NEPA process is intended to help public officials make decisions that are based on understanding of the environmental consequences of their actions and to take actions that protect, restore, and enhance the environment. Federal agencies are to use practical means to restore and enhance the quality of the human environment and to avoid or minimize any possible adverse effects of their actions upon the quality of the human environment. They are also expected to identify and assess actions that will have similar objectives.

The NEPA provisions are supposed to be applied early in the process so that the environmental effects and values of the action can be identified in adequate detail to allow for economic and technical analyses. In this initial phase of the process, significant environmental issues that deserve further study are identified and insignificant issues are de-emphasized, thereby narrowing the scope of the environmental impact statement. The act requires procedures to identify projects that clearly require EIS preparation, determine when an environmental assessment (EA) should be completed, or ascertain when to prepare a finding of no significant impact when the agency's EA leads to a determination that an EIS is not necessary.

Congress did not attempt to anticipate the administrative adjustments that would be required in order to apply the act to the widely varied activities of the federal government (Cramton & Berg, 1971). Thus, the primary impact of NEPA has been largely limited to major federal actions, ignoring the requirement for an EIS for any proposal for legislation or any major federal action which "significantly affects the quality of the human environment" (Robinson, et. al., 1979).

Questions regarding what constitutes a "federal action," a "major action," or "significant effects" have largely been left to the courts to decide. Determining the sufficiency of an EIS has been another problem for the courts to resolve. Although the number of suits brought against federal agencies has steadily decreased since implementation of NEPA, questions still exist as to whether the act simply provided an instrument to stall or kill development projects. Although NEPA is a policy act, it is widely interpreted by lawyers, judges, and journalists as being essentially procedural because the legal profession is primarily concerned with the specific performance that is stipulated by the act and open to challenge and litigation in the courts.

Has NEPA simply become a powerful tool used by special interest groups to press their concerns? Many observers hold this view and believe it is a potential problem with this legislation. Others have objected to NEPA on the grounds that incorporation of an EIS into the decision-making process would enable citizens of another country to employ U.S. courts to block actions proposed by their own country. This could have a significant impact on the caseload of our court system and place potential liability on the United State for the impacts of a project implemented in another country after the impact assessment was performed by experts in the host country.

L. K. Caldwell, considered the architect of NEPA, believes that Congress and the president have generally ignored implementation of the national policy. While NEPA has been largely successful at forcing government agencies to ascertain the probable consequences of their actions, Caldwell states that the impact analysis and evaluation involved in an EIS are not sufficient to achieve NEPA's goals. He calls for a constitutional amendment to fully achieve the intent of the act (Caldwell, 1989).

It is expected that some would support this contention, while others would reject it out of hand. Although society might view environmental issues as increasingly important, it is commonly believed that such support is not broad enough to encompass the passage of a constitutional amendment. There is no indication that NEPA is the unproclaimed answer to global environmental problems or that its embodiment in a treaty would have much useful effect on the major forces behind global environmental impacts.

There is considerable evidence that the environmental assessment process is already employed by a number of industrialized and developing countries (Atkeson, 1989). Multilateral development banks (MDBs) have already instituted procedures for environmental assessments (EAs). The U.S. Agency for International Development (USAID) procedures are a good model for international projects. The United Nations Environmental Programme is considering an international treaty dealing with incorporation of the EIS process. Reaction by American and international experts concerning the EIS process, however, raises questions about the appropriateness of requiring the EIS, especially in view of the fact that all countries may not consider environmental quality to be a basic right.

The additional benefits gained from enacting action-forcing legislation are unknown at present. U.S.A.I.D.'s procedures are already action-forcing and presumably that is the intent of the MDBs. At this time, however, it is appropriate to question how much the addition of such legislation will improve the environmental sensitivity of foreign countries. Not only do developing and developed countries differ in their political atmosphere and attitudes toward the environment, but there is also a wide variation in their ability to pay for environmental protection. In general, human activities undertaken in developing countries usually cause local environmental degradation, while those in developed nations tend to create global environmental problems (Ehrlich, 1990).

Two frequent objections made by scientists to NEPA have been that the state of science is seldom adequate to assess the environmental impact of human activities and that the use of science in a political context runs the risk of corrupting science--the consequence being the dishonest or distorted use of science. In the past critics of NEPA have alleged that the EIS was an instrument of "bad science"; however, it is now generally conceded that there have been improvements in environmental science, and thus the quality of the more recent EISs should be improved.

In the 1960s, air and water pollution were the principal environmental concerns in the United States. From the perspective of the public, aesthetic values contributed greatly to the determination of the quality of our environment. Waterbodies with reported fishkills or contaminated with sewage, garbage, or industrial waste was unappealing. Today, the U.S. environmental program has shifted its focus on control of toxic and hazardous chemicals discharged into the environment, instead of disease-causing agents that formerly occupied our attention. However, disease-causing agents are still of major concern to the developing countries.

If legislation requiring environment impact statements is passed, criteria might be imposed on lesser developed countries (LDC) that would preclude them from achieving success in providing for clean drinking water and the sewage collection and treatment. Moreover many LDCs have yet to address the fundamental needs of public health. Program maturity, therefore, differs significantly throughout the world, and congressional action might inadvertently misdirect the efforts of developing countries.

When people are starving, environmental problems seen insignificant. Impoverished people generally rank their needs in the order of agriculture, public health, and then, perhaps, environmental protection (Carter, 1990). More important to them might be technology to triple or quadruple their grain production per acre. Poverty detracts from the significance of environmental issues. Only when people are shown the direct benefit of an action, that protects the environment will their leaders be able to focus on environmental issues. While it is very appropriate for the U.S. to be concerned with addressing global environmental issues, it is equally important to understand the diverse priorities of the many nations on our planet.

LDCs generally view development as being imperative to the very survival of their bulging populations. They tend to regard environmental concern as a luxury that only industrialized nations can afford (Timberlake, 1984; Arad, 1979). In fact, there are some who would say that the environmental standards or criteria used by developed nations are a function of their affluence. These critics point to a correlation between growth in U.S. GNP and increasingly more stringent criteria for air and water pollution that have evolved since the 1960s.

Nevertheless, there is considerable pressure on LDCs to adopt the standards and criteria of the developed and industrialized countries. Yet on the other hand, there is debate as to whether adoption of these standards/criteria has led to any improvement in the environmental quality of these countries or even the developed countries.

The proposed legislation, S 1045, S 1089, etc., calls for the establishment of appropriate environmental criteria that can be applied to projects covered by the MDB efforts. This call for environmental criteria appropriate for LDCs is not new, but who has accepted the challenge of producing the data base? Would this not be a better utilization of U.S. expertise? Is there not a way in which environmental protection and the sustainable development goals of developed countries as well as the more immediate goals of the LDCs could be accommodated more effectively? As the scientific evidence mounts, developed nations will be in a better position to point to examples of the environmental benefits resulting from environmental preservation, thereby encouraging the developing nations to take a more active role.

Multinational development banks have developed and implemented procedures to assess the environmental impacts of the projects that they fund. There are those who would say that their procedures do little more than pay lip service to the review of environmental impacts (Kumar & Sharma, 1988). Critics point to projects costing billions of dollars and affecting millions of people in countries such as India, Botswana, Sudan, and Brazil. They maintain that the lack of a public process makes a sham of the World Bank's environmental review process. It is possibly for this reason that Congress has deemed it necessary to invoke the power of law to ensure that impacts having major environmental consequences are reconciled before the project design is completed.

USAID uses a multi-step process. The purpose of this approach is to ensure that the environmental consequences of USAID-financed activities are identified and considered by both USAID and the host country prior to reaching the final decision to proceed and that appropriate environmental safeguards are adopted. Their program also produces capacity building within the host country, identifies impacts upon the environment and the biosphere, and leads to the definition of environmental factors that constrain development. Restoration of the renewable resource is an important goal of USAID policy.

The USAID process begins with an Initial Environmental Examination that provides a brief statement of the factual basis for a Threshold Decision, that is, whether an EA or an EIS will be required. The key to making this determination is whether the proposed action is a major action "significantly affecting" the environment (22 CFR Part 216). "Significant effect" is defined as doing significant harm to the environment. If such an effect is predicted, a Positive Threshold Decision is made. USAID, following the procedures prescribed by NEPA, has defined Classes of Actions that would normally be expected to have a significant effect on the environment. Thereafter, either an EA or an EIS will be prepared for the project unless there is justification under the USAID process for making a Negative Declaration. AID's procedures comply with NEPA. They provide an excellent model for other countries and MDBs whose procedures are in the formative stages or could benefit by additions.

In the late 1970s, the Asian Development Bank (ADB) concluded that it must systematize its approach to environmental issues and incorporate environmental concerns into each stage of the project cycle. Between 1981 and 1987, over 3,000 development project reports were reviewed, 1,102 of which were the subject of formal comments from Environmental Specialists. These reviews advised project staff about the significance of potential environmental impacts and provided detailed remedial measures where necessary. The opportunity was also taken, where appropriate, to delineate the wider environmental implications of the project (e.g., water resources development, resettlement of tribal people, rural development opportunities, etc.) and to emphasize the advantage of conducting environmental assessments in the planning and design phase (ADB, 1988).

Environmental Specialists review the ADB's economic development projects. This review first involves the identification of potentially significant environmental impacts associated with the proposed development projects; then agreement is reached on the appropriate budgetary provisions for the necessary services. This is achieved, in part, by dividing the proposed ADB projects into four broad impact categories that reflect the severity of their potential environmental impacts and thus their need for environmental analysis:

Category A:	Projects rarely having significant adverse environmental impacts;
Category B:	Those generally inducing significant adverse impacts, but which can be readily identified and quantified, and for which remedial measures can be prescribed without much difficulty;
Category C:	Projects invariably having significant adverse impacts requiring detailed environmental analysis; and
Category D:	Environmentally oriented projects.

To date, the ADB has published several Environmental Guidelines to help staff determine whether or not a proposed project is likely to generate significant environmental impacts--adverse or beneficial. Since formalizing its environmental policy in 1980, the ADB has moved beyond the exploratory stage in the field of environmental planning and management and has now established a framework in which this important but hitherto neglected dimension can be blended with the overall objectives and strategies of socioeconomic development (ADB, 1988).

Like the ADB, the World Bank (Bank) has also adopted environmental assessment procedures. In addition, the Bank has identified categories of projects for which an EA might be either necessary or unnecessary. The EA must be submitted to the Bank before Bank appraisal. The borrower is expected to describe how major environmental issues have been resolved or are to be addressed, noting any proposed conditionality. The EA's recommendations are expected to reflect the borrower's consultations with the NGO's and other affected groups as a basis for formal environmental clearance prior to the authorization of negotiations with the Bank. EAs also provide the basis for supervising the environmental aspects of project implementation (World Bank, 1989).

For all practical purposes, the scientific aspects of all of these procedures are very similar. Terminology and structure of the overall process differ, as does legal recourse.

Nevertheless, they all have the same objective--identifying the environmental impact of MDB-financed development projects. From experience, the U.S. consulting engineering profession knows that the conduct of environmental assessments and preparation of environmental impact statements are complex and difficult processes. This group also supports the proposed effort for resource-sustainable development for countries at all stages of development. Throughout the world, the U.S. consulting engineer has been at the forefront of the development of methodology for preparing EISs and managing environmental programs and projects.

Those companies engaged in consulting generally lack the full complement of specialists required to assess large projects and thus form consortiums or teams to address the more complex problems. Because of their experience in the field, however, these firms are aware of the unsupportable burden that may be placed on developing countries if they are required to meet U.S. NEPA requirements too quickly.

All developing countries are unique and must not have requirements imposed upon them across the board. Such requirements could delay and even paralyze crucial development efforts. Shortage of trained staff, general lack of experience with a public process, differing priorities, and introduction of a litigious culture are all factors to be weighed when considering alternatives to Congress' call for application of the NEPA EIS process. Furthermore, it is doubtful whether these countries would have the resources necessary to implement a NEPA EIS approach. An approach that would be effective is one that assists countries in improving their capacities to assess environmental needs, while ensuring that the best expertise is used to assess priority projects in the interim. This, in short, is the role of assistance of U.S. consulting engineers and scientists.

To assist developing countries in strengthening their systems, the following kinds of actions should be taken:

- Designating USAID as the lead agency to transfer environmental assessment expertise to LDCs and MDBs.
- Programs for their national and state-level legislators, e.g., visits to their U.S. counterparts to gain an understanding of how environmental laws are developed.
- Assistance from U.S. agencies to their counterparts in developing countries, where appropriate, on administrative support systems, recruitment and classification of personnel, on-the-job training, and other areas as needed.
- Assistance from U.S. universities, technical consultants, professional associations, and technical schools on curriculum development that will enable countries to produce better-qualified environmental specialists.
- Short- and long-term training courses in the U.S. and by U.S. specialists in-country to train engineers, scientists, technicians, and managers.
- Development of improved contractual arrangements for technology transfer by U.S. companies to their developing country associates and subcontractors.
- Provisions for on-site project training of developing country engineers and specialists on environmental projects being implemented in the U.S.
- Development of a process within the U.S. Environmental Protection Agency's standard/criteria setting process that would assess the impact of U.S. environmental standards/criteria on LDCs.

Whether any of the previously mentioned bills become law or not, it is clear that development projects will continue to be closely scrutinized for their environmental effects. Imposition of U.S. standards and law on the sovereignty of host countries is not likely to improve the quality of those reviews. It is quite possible that the full intent of NEPA needs to be brought to bear on this issue. Perhaps such an action will point Congress in the right direction.

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STRATEGIES FOR SOURCE REDUCTION

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ABSTRACT

The Strategies for Source Reduction Project is exploring changes in product design and use as ways to help reduce problems in the municipal solid waste stream. The project, being conducted by The Conservation Foundation with funding from the U.S. Environmental Protection Agency, is directed by a broad-based steering committee that will complete its work in the fall of 1990. Three issues relating to the environmental effects of products are highlighted in this paper among the various project activities designed to influence national policies.

Definitions for municipal solid waste source reduction abound. But without widespread agreement on what source reduction means, national policies cannot achieve their full potential. This project is grounded in the perspective that source reduction: 1) involves a range of activities outside the management of the waste stream, 2) is a resource conservation measure, and 3) should not increase the net amount or toxicity of wastes generated over a product's life.

Public interest in the tools for measuring the environmental effects of products has surged recently. A one-day forum was held to explore policy issues emerging during this time of green consumerism and renewed concern for the environment. Among the many issues identified, panelists discussed how the expansion from private to public uses of product life information might require changes in the way studies are conducted and results communicated.

One of the uses of product life information is in labeling programs that intend to help consumers choose products that are environmentally preferred. The steering committee has developed recommendations that can be used to help overcome challenges in designing an effective program and to evaluate alternative approaches to product labeling. Several of those recommendations, including the need to avoid multiple programs, are addressed.

How can changes in the design and use of products help reduce the volume and toxicity of the waste communities must manage? That question is being addressed for the first time on a nationwide basis by the Strategies for Source Reduction project at the Conservation Foundation. While the project will not be completed until the fall of 1990, this paper highlights several issues addressed so far: the definition of source reduction, policy issues surrounding the nature and use of product life or "life cycle" studies, and product labeling programs.

The Strategies for Source Reduction project grew out of several recommendations in EPA's Agenda for Action for solid waste management. Undertaken with funding from EPA's Municipal Solid Waste Program, the project is designed to provide pragmatic guidance for those seeking to influence source reduction at the national level. A 19-member steering committee was convened in the fall of 1990 to guide the analysis and to develop project recommendations. Members represent:

- federal and state governments;
- authorities responsible for managing municipal waste at the national and local level;
- manufacturers and a retail chain; and,
- national and local public interest groups, as well as the academic community.

This diversity in perspectives is essential to help forge a nationwide consensus on policies that encourage source reduction. We have not focused on packaging per se, because there are other major efforts underway doing just that--such as the Source Reduction Council of the Coalition of Northeast Governors. Nor have we sought to develop a comprehensive list of actions for all sectors to take, or to conduct a comprehensive analysis of incentives and disincentives for source reduction. Such recommendations would run counter to our belief that many source reduction problems and solutions must be dealt with by the various sectors concerned and at the community and state level.

WANTED: A COMMON DEFINITION FOR SOURCE REDUCTION

Recently, another organization conducted a survey of all the definitions for source reduction being used around the country. The tally was about twenty then, and that number probably has grown. Some of the definitions include recycling; others adamantly exclude any form of waste management. Some emphasize resource conservation; others don't mention it at all. Some definitions are lengthy descriptions; others simply a sentence or two.

One of our first priorities, then, was to try to build a common understanding of what this Steering Committee meant by source reduction for its own activities, and further, to make that definition available for others to adopt. Will it prove to be just one more definition? Hopefully not. By bringing together the different needs and viewpoints represented in this project, we believe the resulting definition will help establish common guidelines for the goals and priorities we need to make source reduction happen in this country. It has not been easy to reach a definition that meets all expectations but we are very close. To start with, we have defined source reduction to be:

> ....the design, manufacture, purchase or use of materials or products (including packages) to reduce their amount or toxicity before they enter the municipal solid waste stream.

Furthermore, our final definition will include two related concepts:

> ....a recognition that source reduction is a resource conservation measure; and
>
> ....that source reduction should not increase the net amount or toxicity of wastes generated throughout the life of a product.

These central ideas--that source reduction involves a whole range of activities outside the management of the waste stream; that it serves to conserve resources; and that it recognizes effects stemming from the entire life of a product--are pivotal to the entire context of our project. The latter concept, for example, leads to another issue our project has dealt with as discussed below.

PRODUCT LIFE ASSESSMENTS: POLICY ISSUES UNLIMITED

On May 14, the Conservation Foundation, at the suggestion of our Steering Committee, brought together a panel of twelve individuals to explore the nature and use of what we are calling product life assessments. Sometimes known as life-cycle or cradle-to-grave studies, these assessments are used to identify the resource effects associated with a product over its entire life spectrum. A comprehensive study of this type identifies energy use, material inputs, and types of pollution generated during a product's life: from extraction and processing of raw materials, to manufacture and transport of a product to the marketplace, and finally, to use and disposal of the product.

Product life assessments are not a creation of the last year or so. The first studies were conducted in the late 1960's and early 1970's during a period in which energy efficiency, recycling and solid waste were issues of public concern. In fact, at least two such assessments were performed in the late 1970's to compare alternative products much in discussion today: disposable versus reusable diapers. Many more studies during that period, however, focused on the energy and environmental impacts of packaging alternatives--particularly beverage containers.

While such studies are not new, they recently have surfaced as an issue of great public interest and controversy. Private and public sector demand for product life assessments has surged. One private firm is doing twice as many studies this year as in the previous decade or so; a nonprofit firm is undertaking a study of unprecedented scale for a consortium of states and other interests; EPA has launched a major research effort to design and use product life assessments.

It is not difficult to understand the surge in interest during this era of renewed environmental concern and green consumerism. Product life information might be used by companies in selecting which products to sell, by consumers in choosing among products offered and by governments in setting policies involving specific materials or substances. Architectural and industrial design associations might use product life information in specifications for their clients and professions. The array of potential uses--and misuses--is daunting. Which is why we held the forum.

Despite the enormous role of product life assessments, there is no clear consensus among prospective users and developers of the information on: what the study should actually consist of, which analytic methods and data are appropriate, whether or not technical detail should be available to the public, and a host of other issues. Lack of resolution on such issues poses an obstacle to their constructive use and opens the door to abuse.

Our forum did not presume to resolve such issues. Rather, it was intended to serve as an early opportunity to identify and explore exactly what the policy issues were surrounding these studies to help speed their resolution. We are in the process of compiling a report on that discussion, but several issues are presented here.

A NEW PUBLIC ARENA

The expanding use of product life information for development and marketing brings them into the public arena as never before. Issues have become more complex and the "groundrules" appear to be changing quickly. This expanded context carries with it new concerns regarding the analytic tools themselves and sources of information. For example, there will be considerable pressure to examine underlying data and assumptions in order to verify study conclusions. That can come in conflict with the confidentiality of company data, which if perceived to be a threat, could affect the quality of information made available to consultants carrying out the studies. New methods of building and standardizing databases, one panelist likened to economic input-output matrices, may need to be developed to resolve this conflict.

MEASURING ENVIRONMENTAL EFFECTS

One of the major issues raised at the forum concerned how far the analysis should go in identifying and weighting environmental effects. This topic generated numerous opinions and points of view. For example, some panelists believed that product life assessments, for public uses in particular, will be incomplete without measures of risk assessment. Others believe that including risk data would make the analysis too unwieldy for widespread use. Some believe that risk assessment is beyond the scope of the studies, partially because a floor of protection is furnished already by federal laws and regulations. Some panelists, however, pointed to the recent shift toward pollution prevention as a good example of the changing groundrules. By getting at the source of pollution through product design, we are looking at an expanding universe of pollutants and their effects. Ability to meet OSHA or EPA standards alone may no longer be sufficient.

Even more basic, however, is the question concerning whether or not individual pollutants should be weighted in some way. Many studies tend to summarize the amounts of individual pollutants by their categories of release, such as water and air pollutants. Some panelists pointed out that adding up individual pollutants in this manner implicitly assigns an equal weight to each. Since there may be disagreement over the relative weighting of pollutants, studies could either identify and list all amounts of pollutants for the reader to interpret or make assumptions explicit.

COMMUNICATING RESULTS

The challenge in communicating product life results to the public was another point of discussion. Clearly there is tension between simplicity and accuracy. If results are too simple, the inherent complexity of the data may be lost. If too complex, the study will die of its own weight. All parties concerned with product life assessments will need to address these tradeoffs and develop workable solutions.

STREAMLINING THE PROCESS

Our environmental problems are such that we may not be able to postpone work until hundreds, or thousands, of product life assessments are performed. Many panelists, if not all, seemed to agree that we may need to devise different tools for different uses; there may not be, in fact, a single instrument called a "product life assessment." To avoid the quagmire of needless complexity, we may need to develop sound but efficient shortcuts for evaluating relative environmental effects of alternative products and materials. One immediate issue, for example, will be how to tailor and use these assessments for the product labeling programs currently proposed in the United States.

THERE'S LABELING AND THEN THERE'S LABELING

Our Steering Committee has evaluated two different types of labeling approaches that could be used to help consumers choose products on the basis of their environmental characteristics. If effective, such programs could harness the private market to produce goods that are compatible with source reduction, i.e. goods that generate less waste, and waste that is less toxic.

The first type, "environmentally preferred" labeling, is the kind practiced in West Germany and Canada and currently proposed by Green Seal, Inc., for use in the United States. Such an approach is voluntary (manufacturers can choose whether to apply); positive (only relatively superior products are distinguished); and is based on specific technical criteria such as some of the factors included in product life assessments discussed above.

Environmentally preferred labelling is quite different from an alternative called "standard setting." This method controls the use of certain terms (such as "recyclable" or "recycled content") by defining the terms and establishing conditions for their use. Standards could also be used to control the use of symbols such as the three-arrow recycling logo. If implemented by a government agency through regulations, as being considered in the northeast states, the standards could be mandatory. Standards developed by industry associations or independent testing organizations can also be implemented on a voluntary basis.

Our project has not endorsed any particular labeling program--either existing or proposed. It has, however, laid out certain guidelines and recommendations that can be used to help evaluate labeling programs currently being explored at the national, state, or community level. For example, the steering committee recommends that a labeling program should base its criteria on product life assessments. The discussion below reflects and amplifies on several other points concerning an environmentally preferred labeling program.

IMPLEMENT AT THE NATIONAL LEVEL

Product labeling should be done at the national level, preferably through a single program. The logic to that recommendation would seem clear enough. Labeling is intended to reduce consumer confusion about the myriad of products available in stores. Even with a single program, there is some potential for confusion because consumers may misinterpret the label's meaning. For example, a consumer might believe it safe to pour a household paint down the drain because they think the label means the product is completely benign. That type of educational challenge is why countries are steadily abandoning labels that read "environmentally friendly" or other absolute terms that imply that a product has no effect on the environment or is even "good" for the environment.

Now multiply that challenge with a variety of labeling programs that are likely to be inconsistent with each other. Clearly, multiple programs pose a greater risk of aggravating the confusion they intend to remedy. Moreover, a major consumer turnoff to such an educational tool could have long term consequences quite at odds with our current thrust toward pollution prevention. There is another practical reason for recommending a national program: it would reduce the burdens on companies associated with multiple labeling programs.

CAREFULLY DEFINE THE CATEGORIES

The categories used to label products should be selected with great care. An environmentally preferred label provides relative information only about products within some logically designated category, such as paper products, detergents, light bulbs, etc. If not defined properly, however, the category could exclude alternative products that clearly are superior for the use intended. One example of that can be found in West Germany's Blue Angel program. In that program, low-solvent paints and varnishes are eligible for the logo while latex paints that contain no organic solvents are not, since no one brand of latex paint is environmentally superior. Canada' Environmental Choice program solves that problem by selecting low pollution water-based paints as a category in itself.

STRENGTHEN THE CRITERIA OVER TIME

Criteria need to be reevaluated and strengthened periodically. Source reduction--as reflected in a product's right to bear a label--is not a static level of accomplishment. As manufacturers seek new and innovative ways to reduce waste,competition should drive technological innovation further. Within each product category, therefore, criteria should be reviewed periodically to provide an incentive for continued innovation.

INVOLVE INDUSTRY

Finally, among other recommendations made, industry should be involved in any national labeling program. While the exact nature and degree of involvement may take various forms, it is clear that labeling will not accomplish its potential for source reduction if manufacturers choose not to participate. Such participation can be encouraged through industry involvement in the labeling program effort. It also will be encouraged by an open and transparent decision-making process that draws on public input and comment.

OTHER PROJECT ACTIVITIES

This paper has focused on three of the issues being explored by the Strategies for Source Reduction project. Two of those issues--product life assessments and labeling programs--will require continued study before we realize their full potential. But we need not await further research to move forward on many other fronts. This conference, with its many success stories, testifies to that. Many steps in source reduction are being carried out throughout the country, often driven by local initiatives.

Another element of our forthcoming report, therefore, is to demonstrate just a few of those actions that can be undertaken without the need for any additional research. An example of "things we can do now" is the use of volume-based disposal fees for municipal trash pickup. Such fees provide a direct and tangible incentive for households to reduce the wastes they generate. It is a straightforward concept that is working well in cities ranging from Seattle, Washington to High Bridge, New Jersey.

Another element of the project, and a major one at that, is our effort to develop a framework that others can use to identify source reduction opportunities in the municipal solid waste stream. As currently envisioned, the framework's set of questions could guide an analyst through a process of selecting priorities for study, identifying source reduction techniques that might pertain to a particular kind of product, and addressing issues that could affect whether or not a strategy is desirable or feasible. By developing this kind of "roadmap," it is our hope to extend the results of our analysis manyfold. To make sure the framework does indeed work, we are testing it with several product categories and will share the results of that application in our final report.

CONCLUSIONS

The Strategies for Source Reduction project is just one step in moving forward with national policy that helps address our municipal solid waste problems and to improve the state of the environment. This conference is testimony to the range of actors that must be involved in reducing wastes at the source. Actions at the community level surely will play a major role in determining how much we accomplish. By structuring a steering committee to include actors at the local level, as well as other sectors, this project recognizes that many of best and most innovative ideas spring from the community. And that local support for a national program can determine whether or not it succeeds.

MULTIMEDIA LOCAL GOVERNMENT POLLUTION PREVENTION PROGRAMS

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INTRODUCTION

While the United States has entered a period of extreme waste management problems, nowhere is the problem more severe than in the hazardous waste arena. Hazardous waste landfills are closing, air pollution is getting worse and the wildlife in our waterways is dying a toxic death. The EPA database of environmental releases indicates that reporting facilities released over 4 billion pounds of toxic chemicals in 1988. What is most revealing about this statistic is that it only includes a small subset of U.S. waste-producing facilities. While less than 20,000 polluters reported their releases to the EPA, health officials in Los Angeles estimate that there are over 20,000 hazardous waste generators in Los Angeles County alone.

Hazardous waste reduction, reducing the use of toxic chemicals and generation of hazardous waste, is the superior solution to our waste management crisis. Through input changes, operational improvements, production process changes and product reformulations, it is possible to significantly reduce the amount of toxic chemicals used and hazardous waste generated. While treating and/or recycling waste always results in the release of some form of the pollutants to some part of the environment, waste reduction eliminates waste generation and the need for treatment and recycling.

WASTE REDUCTION IMPLEMENTATION: THE ROLE OF GOVERNMENTS

While waste reduction often saves industry money along with improving the environment, it is often necessary to provide educational, economic and technical resources to help industry discover the benefits of waste reduction. While the federal and state governments encourage industry to reduce waste generation, they are unable and unwilling to effectively solve the problem alone. Each industrial facility presents unique opportunities for waste reduction that cannot be fully addressed at the national or state level. In addition, federal and state regulatory agencies spend extremely small percentages of their budgets on waste reduction activities. The inadequacies of the federal and state governments leave local governments with a significant role to play in encouraging industrial waste reduction.

There are two major reasons why local agencies are often better suited to encourage waste reduction than their state and federal counterparts:

- Local governments have the most to gain in waste reduction activities. By reducing the amount of pollution created locally, they are reducing the risks posed to local citizens, saving local businesses money and improving the economic vitality of their community. Additionally, waste reduction reduces the need for highly unpopular hazardous waste management facilities; and
- Local agency staff have the most contact with local industries. There are many more inspectors at the local level than there are at the state and federal level. Local staff have a greater opportunity to encourage waste reduction and a greater sense of partnership with local industries.

Finally, given the pollution problems facing the earth, it is imperative for all levels of government to be intimately involved in solving them.

LOCAL GOVERNMENT HAZARDOUS WASTE REDUCTION PROGRAMS

California local governments have a history of implementing successful waste minimization programs. Led by Ventura County in 1986, many local governments have established educational, technical assistance and regulatory programs designed to encourage local industries to reduce their hazardous waste generation. Tools employed by local governments include having workshops for local businesses on hazardous waste reduction, establishing a waste reduction library, handing out ready-to-use waste reduction resources, providing in-depth technical assistance to local businesses, and establishing regulatory planning requirements for waste reduction.

COMMISSION ACTIVITIES IN HAZARDOUS WASTE REDUCTION

For the past three years, the Commission (See Appendix A for a background on the Local Government Commission) has focused on local government programs to reduce the use of hazardous substances and the generation of hazardous wastes. The waste minimization project began with the distribution of a guidebook and model resolution establishing waste minimization as the priority hazardous waste management strategy. After providing important background information at conferences and workshops, over 60 local governments in California adopted our model resolution.

With the passage of the Hazardous Waste Management Planning Act of 1986 (California Assembly Bill 2948), the Commission worked with counties to get waste minimization established as a priority in county hazardous waste management plans. All 58 counties in the state have now established waste minimization as their priority in their plans.

During the fall of 1987, the Commission trained 500 local government officials at a series of four regional waste minimization workshops. An ongoing network evolved from these activities. A bimonthly newsletter, the "Waste Minimization Update," is published by the Commission to keep workshop participants, Commission members, and others in touch with the progress of state and local programs.

After the workshops, guidebooks were developed to assist local agencies in implementing waste minimization programs. Each was the result of an intensive study of model programs around the nation and of extensive peer review. Low Cost Ways to Promote Hazardous Waste Minimization is a two-volume set designed to assist local governments in implementing a waste minimization program which does not require additional staff or excessive resources. Minimizing Hazardous Wastes: Regulatory Options for Local Governments details how to initiate local regulatory efforts that encourage waste minimization. Reducing Industrial Toxic Wastes and Discharges: The Role of POTWs is designed specifically for water pollution control agencies. It details how these agencies can use existing tools and resources to encourage reductions in the amount of toxic discharges entering their system.

After these guidebooks were developed, the Commission obtained funding from the California Department of Health Services, San Francisco Foundation, Harder Foundation, Sierra Foundation and C.S. Fund to provide policy assistance to communities throughout California to help in the establishment of local hazardous waste minimization programs. As a part of this program, we have facilitated the delivery of introductory-level training programs for local agency staff.

Policy assistance can take a variety of forms. At its simplest, technical assistance consists of conducting one or more phone conversations with key local staff and/or elected officials to help them develop a program. Information provided can include innovative program ideas from other local governments, resources that are available to support a local effort, and other basic information. Written comments are also frequently desired. Along with the above, more intensive technical assistance activities include making site visits, repeatedly phoning local staff, researching issues, and customizing resources for the local agency. Finally, the most complex technical assistance activities involve more intensive staff resources. As an example of this type of activity, the Commission organized a training session on waste reduction exclusively for the staff of the Los Angeles County Health Department.

As a result of Commission activities and other trends, 25 California local governments, representing nearly 80% of California's population, are implementing hazardous waste reduction programs.

THE COMMISSION'S MULTIMEDIA ACTIVITIES

After working in this area for several years, the Commission has recognized that hazardous wastes are often transferred from one medium to another as a means of disposal, e.g., a treatment unit removes heavy metals from wastewater only to have the metals then deposited in a landfill. This waste transfer does not result in *real* reductions in the use of hazardous materials or generation of hazardous waste.

To reduce this problem, the Commission has worked on designing *multimedia programs*. Multimedia reduction programs work to reduce toxic releases to the land, water and air. By focusing on coordinating the efforts of environmental health, water pollution control and air pollution control agencies, the Commission is assisting local governments develop programs that will maximize environmental and economic benefits. With varied amounts of support from the Commission, Contra Costa, Los Angeles, Orange, San Francisco, Santa Clara and Santa Cruz counties have taken the initials steps toward establishing a multimedia program.

To encourage other local governments to engage in multimedia waste reduction programs, the Commission has developed a model multimedia resolution and distributed it to key contacts throughout the state. The resolution is included as Appendix B. During presentations, a multimedia handout, developed by the Commission is distributed. This handout, laying out a four-step suggested process, is included as Appendix C.

RESULTS

MULTIMEDIA LOCAL GOVERNMENT ACTIVITIES

Several California counties have taken the initial steps toward developing multimedia programs. The following case studies are excerpted from the Local Government Commission's "Waste Minimization Update":

> The County Sanitation Districts of Orange County, Orange County Health Care Agency and South Coast Air Quality Management District have established the "Orange County Multi-Agency Task Force on Waste Minimization." With

representatives from the agencies regulating wastes released to the water, land and air, the task force is the first multimedia, waste minimization body to be formalized in California. According to Rich von Langen of the County Sanitation Districts, "The Task Force was established with three major goals: 1) To educate the business community on multimedia waste minimization; 2) To provide technical assistance on multimedia waste minimization audits; and 3) To incorporate waste minimization into the permitting and enforcement aspects of all three regulatory agencies." Task Force members have begun compiling a library of educational materials and resources to support their educational efforts. In addition, they recently compared their individual lists of top companies and targeted 41 companies to receive the first multimedia waste minimization technical assistance. After sharing information and about their individual programs and planning the multimedia program for several months, the Task Force sponsoring a joint workshop on November 2, 1989.

The Santa Cruz County Environmental Health Department has arranged a series of meetings with all of the water pollution control agencies in the County. Representatives from the agencies discussed the pollution-control and minimization issues facing the County and opportunities for coordinating these activities. The group identified the need to tighten the "regulatory loop" between media-specific agencies and improve the system for notifying agencies about new hazardous materials users in the community. Cross-training inspectors and coordinating inspections were two activities discussed at the meeting. The group has decided to meet monthly to flush out these issues in greater depth and develop more closely coordinated programs.

Los Angeles County has had a "Hazardous Materials Coordinating Committee" for several years. At a recent meeting, the Committee established a Minimization Subcommittee to work on coordinating and expanding the County's minimization efforts. Representatives from the water pollution control, air pollution control and environmental health agencies will participate in the Subcommittee. After the first meeting, one participant commented that "it was great to see a representative from another agency realize that their pollution-control 'solutions' were creating pollution problems for us. I hope that, in the future, all agencies will realize that pollution prevention, eliminating the generation of a waste, should be considered as a potential 'best management technology' when developing regulations."

BARRIERS TO PROGRAM DEVELOPMENT

As may be expected, it can be very difficult to get media-specific regulatory agencies to cooperate with each other. The long histories of each agency often interfere with their ability to cooperate and their ability to even consider the impacts that their actions and regulations may have on another environmental medium.

A second problem is the difference in the number and type of pollutants that each agency regulates. While environmental health and water pollution control agencies *generally* regulate the same toxic pollutants, air pollution control agencies in California focus on pollutants contributing to ozone formation and, to a lesser extent, carbon monoxide. Few regulations in California limit the emission of pollutants based on their toxicity or health threat except as they relate to ozone formation.

A fourth problem is the lack of staff resources available to implement multimedia problems. Local agencies, especially in smaller jurisdictions, often have a difficult time implementing their own media-specific waste reduction programs. Many of them are unable to adequately enforce even their own regulations and are not ready to implement a waste reduction program. Considering multimedia programs can be completely unrealistic for these agencies until they are ready to implement their own reduction program.

A final problem is the presence of bureaucratic inertia. Even when resources are available, agency employees are often unmotivated and unwilling to consider any expansion in their role.

FUTURE PLANS

The Commission is currently preparing a guidebook on waste reduction opportunities for air pollution control agencies. Once completed, this guidebook will complement the resources already developed by the Commission for environmental health and water pollution control agencies.

The Commission has assisted the California Department of Health Services obtain a grant from the U.S. Environmental Protection Agency to develop multimedia waste reduction programs at the local level. Under this grant, the Commission will be producing six training workshops around the state. Each three-day workshop will focus on multimedia waste reduction opportunities for various industries. In addition, a series of roundtable discussions involving key contacts from the federal, state and local governments regulating pollutant releases will be developed.

Another aspect of this grant is the development of four model multimedia reduction program. Grant funds will help Ventura County, San Diego County, San Bernardino County, and Orange County make the connections between regulatory agencies needed to develop multimedia programs.

APPENDIX A

ORGANIZATIONAL BACKGROUND

The Local Government Commission is a nonprofit, nonpartisan, membership association of over 350 county supervisors, city councilmembers and mayors which serves as a "think tank" to help locally elected officials develop innovative programs and policies to address the problems of our day. The Commission researches and develops model programs and policies primarily addressing environmental concerns. Since 1979, the Local Government Commission has addressed conservation and alternative energy development, the prevention of toxic contamination, transportation alternatives, and recycling and solid waste reduction. We have written over 30 how-to guidebooks which provide specific policy options, stimulating numerous programs in California communities.

The Commission has its roots in the Office of the Governor of California. In 1979, a special "Council" of experts from the private sector was appointed by the Governor and assigned the task of devising a plan to promote energy conservation and alternative energy development in the State. The group identified local government as key to the implementation of effective policy.

The Governor acted on the Council's advice by establishing the "SolarCal Local Government Commission" in the State's Department of Business and Transportation. About 35 city councilmembers, mayors and county supervisors were appointed and charged with the task of implementing local government energy conservation and alternative energy projects. The group was provided with model programs and policies, invited to conferences and workshops, and was given technical assistance.

In 1983, a new governor phased out most State energy programs including the SolarCal Local Government Commission and the members voted to build the Commission as a nonprofit, membership organization. Between 1983 and 1987, the organization focused primarily on toxics issues. In 1988, recycling and solid waste source reduction were added as major program elements. The Commission has also provided limited programs on child care, water conservation, growth management, and transportation.

In the area of solid waste, the Commission has had a particular focus on local government procurement policies which favor the purchase of recycled materials. When the Commission first began working on this issue over a year ago, only one local government had developed a procurement policy. Now, over 22 cities and counties in California have established formal policies to purchase recycled products and many more such policies are in the planning stages.

APPENDIX B

MODEL RESOLUTION FOR INITIATING A MULTIMEDIA ENVIRONMENTAL POLLUTION PREVENTION EFFORT IN THE CITY/COUNTY/DISTRICT OF ___

In the matter of establishing a multimedia program to assist businesses in adopting pollution prevention measures in the City/County/District of _____.

WHEREAS, pollution prevention includes reducing the use of hazardous substances, reducing the generation of waste at the source, and recycling waste to reduce pollutant releases to all environmental media; and

WHEREAS, pollution prevention protects the health and environment of the community, saves businesses money, decreases employee exposure to workplace chemicals, and reduces the need for hazardous waste management facilities; and

WHEREAS, pollutants released to each environmental medium (land, air or water) historically have been regulated separately and without regard to other environmental media, thereby encouraging the transfer of pollutants from one medium to others; and

WHEREAS, these medium-specific regulations have created barriers and reduced incentives for pollution prevention activities; and

WHEREAS, the City/County/District of ____ encourages businesses, where feasible, to employ multimedia pollution prevention practices, rather than treat and/or dispose of toxic chemical waste into the land, air, and water;

NOW THEREFORE BE IT RESOLVED that the ______(lead dept. or division)______ convene a coordinating committee with the city, county and regional agencies regulating pollutant releases to all environmental media for the purposes of sharing information, comparing pollution control activities and regulations, coordinating regulatory efforts, and establishing a multimedia pollution prevention program; and,

OPTIONAL CLAUSES TO STRENGTHEN THE PROPOSAL:

FURTHER, BE IT RESOLVED that the multimedia coordinating committee evaluate the feasibility and appropriateness of educational techniques, technical assistance and regulations to encourage multimedia pollution prevention; and

FURTHER, BE IT RESOLVED that the (lead dept. or division) submit a proposed work program to this Council/Board by ____(date)____ that identifies the multimedia pollution prevention activities selected for implementation, along with a timetable and required financial support; and

FURTHER, BE IT RESOLVED that the (lead dept. or division) submit a progress report to this Council/Board on multimedia coordination activities by ___(date)___.

APPENDIX C HANDOUT USED

Local coordination among the local environmental health/resource management department, the local POTW, and the local air pollution control agency can provide the context for significant environmental gains. Working together, these local agencies can: strengthen the enforcement of traditional pollution control regulations to prevent the transfer of chemical wastes from one medium to another; and develop innovative educational, technical assistance, and regulatory waste minimization programs. Local agencies can work toward these important goals through a 4-step process:

Step 1: Information Sharing Cooperation among the media-specific agencies should begin with information sharing, a sorely needed activity given the fragmented nature of the state and federal toxics regulatory system. Often, the regulators in one arena know surprisingly little of the nuts and bolts of the other media-specific programs.

Step 2: Interagency Regulatory Review Based on the knowledge gained from the first step, each agency should agree to critically analyze its own regulations from several vantage points: (1) Which regulations encourage pollutants to be transferred from the agency's medium of concern to other media? (2) Can the agency's regulations be modified to deter this cross-media transfer? (3) Can the regulations of another agency be modified to prevent the transfer? (4) Which regulations discourage or encourage waste minimization practices? Proposed regulations should also receive this type of review prior to their adoption.

Step 3: Coordinated actions With the information collected under the first two steps, the various agencies can now plan any number of coordinated activities, from interagency agreements to resource sharing, planned division of labor, and other forms of joint actions. Initially the actions may be informal. For example, waste minimization technical assistance efforts could be organized to most effectively utilize the technical expertise within the various media-specific programs. Or, suspected violations could be routinely cross-reported to the proper regulatory agencies. Eventually, the cooperation may become more formal.

Step 4: Integrated Actions: Over time, the multimedia coordination may evolve into a more sophisticated system of joint inspections, integrated waste minimization technical assistance, or integrated enforcement and permitting. Through eliminating redundancy and streamlining regulatory requirements, an integrated system has the potential for significantly cutting program costs and the associated industry fees. It would also reduce the need for firms to work with a multiplicity of different regulatory agencies, currently a costly burden for the nation's businesses.

Due to the media-specific nature of state and federal regulations, integrated actions may be difficult for local agencies to implement if the corresponding state agencies are not actively supporting the concept. However, successful programs can be based on creative intergovernmental *coordination*, which does not require the participating agencies to alter their basic regulatory structure.

MATERIALS SUBSTITUTION AT THE ROCKY FLATS PLANT

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ABSTRACT

The Rocky Flats Plant established a Waste Minimization Program in January 1988. One of the major goals of this program is the elimination of three hazardous solvents: 1,1,1 - trichloroethane (TCA), carbon tetrachloride, and 1,1,2 - trichloro - 1,2,2 trifluoroethane (freon-113).

These solvents are used mainly for cleaning in maintenance and manufacturing throughout the plant. There has been an 80% reduction in the use of TCA and freon-113 in the maintenance and non-plutonium manufacturing areas since January 1988. This reduction of 21,000 gallons per year is based on procurement records.

A plan has been drafted and is under review by the Design Agencies to test alternatives to TCA in the final cleaning of plutonium. Some of the alternatives under consideration are:

1. Water
2. Liquid carbon dioxide
3. A non-hazardous alternative solvent

Testing is already underway to identify alternatives to carbon tetrachloride as an "in process" cleaner in the plutonium

manufacturing areas or changing procedures so a solvent is not needed (i.e. dry machining plutonium instead of using oil).

The employees in the plutonium manufacturing areas reduced their use of carbon tetrachloride from 14,000 gallons in 1988 to 10,500 gallons in 1989 (25% less) through more careful use of this solvent in their cleaning operations.

The Rocky Flats Plant is part of a nationwide nuclear weapons research, development, and production complex administered by the U.S. Department of Energy. The prime operating contractor is EG&G Rocky Flats, Inc.

The primary mission of Rocky Flats is the production of metal and metal components for nuclear weapons. The plant is involved in the fabrication of components from plutonium, uranium, beryllium and stainless steel. Production activities include metal fabrication, assembly, chemical recovery and purification of recyclable transuranic radionuclides, as well as related quality control functions.

Rocky Flats' operations result in the generation of solid, liquid and gaseous waste streams. Waste classifications include:
1) transuranic waste; 2) low-level waste; 3) radioactive mixed waste; 4) hazardous waste; and 5) sanitary waste. Waste handling operations at the plant include on-site storage, transport, treatment, packaging of waste materials for off-site disposal, and on-site sanitary disposal.

Hazardous and mixed waste management activities are regulated by the Colorado Department of Health and U.S. EPA under the Resource Conservation and Recovery Act (RCRA). Site environmental cleanup activities are regulated under both RCRA and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA).

WASTE MINIMIZATION ORGANIZATION

EG&G has established a Waste Minimization Program (WMP) within Environmental and Waste Programs. The WMP Manager reports to the General Manager through the Waste Programs Manager, the Waste Programs Director, and the Associate General Manager for Environmental Restoration and Waste Management, as illustrated in the organization chart provided in Figure 1. Through this chain of command, the WMP Manager has been assigned the responsibility for overseeing the planning, management and implementation of waste minimization activities at the Rocky Flats Plant in accordance with applicable EPA and Colorado Department of Health (CDH) requirements, as well as applicable DOE Orders and EG&G policies.

DESCRIPTION OF PROGRAM

The main priority of the waste minimization program is avoidance of waste generation, or source reduction. The program focuses on source reduction activities that minimize or eliminate the generation of waste, and recycling processes that use, reuse, or reclaim a material from a waste stream.

FIGURE 1
WASTE MINIMIZATION ORGANIZATION CHART

EG&G ROCKY FLATS
GENERAL MANAGER

ENVIRONMENTAL RESTORATION & WASTE MANAGEMENT
ASSOCIATE GENERAL MANAGER

WASTE PROGRAMS
DIRECTOR

ENVIRONMENTAL & WASTE
PROGRAMS MANAGER

WASTE MINIMIZATION
PROGRAM MANAGER

WASTE MINIMIZATION ASSESSMENT

Following EPA assessment guidance (1), a Rocky Flats waste minimization assessment was completed in December 1989. Areas of focus were identified and options for addressing those areas evaluated. Implementation of the selected options is in progress. As part of the Waste Minimization Program, further waste minimization assessments will be conducted annually to track the progress and identify further ideas for implementation. Program goals and program evaluation are based on the results of these assessments.

SOLVENT SUBSTITUTION

One of the major goals of the waste minimization program is the elimination of three hazardous solvents: 1,1,1 - trichloroethane (TCA), carbon tetrachloride and 1,1,2 - trichloro - 1,2,2 - trifluoroethane (freon-113).

These solvents are used mainly for cleaning in maintenance and manufacturing throughout the plant. There has been an 80% reduction in the use of TCA and freon-113 in the maintenance and non-plutonium manufacturing area since January 1987. The reported reduction of 21,000 gallons per year between January 1987 and January 1988 is based on procurement records.

This dramatic reduction is due to substituting aqueous based detergent cleaning for the TCA and freon-113. Water has replaced freon-113 for density measurement of uranium components. The equipment is being installed to eliminate the last major use point of TCA in these areas of the plant. Tables 1 and 2: Table 1 shows the reduction in freon-113 use for 1988 and 1989 and the projected reduction for 1990.(2) Table 2 shows this same information for TCA. With reductions in solvent waste there is also a reduction in the volume of paper and other combustible wastes contaminated with these solvents.

Now the focus of this effort is on the plutonium manufacturing areas. There are three uses of solvents that will be addressed:

1. Cleaning
2. Machining coolant
3. Density measurement

TABLE 1
FREON USE IN NON-PU BUILDINGS

FY 1988	250 gallons/month
FY 1989	64 gallons/month
FY 1990 (projected)	25 gallons/month

TABLE 2
TRICHLOROETHANE USE IN NON-PU BUILDINGS

FY 1988	250 gallons/month
FY 1989	100 gallons/month
FY 1990 (projected)	50 gallons/month

A plan has been drafted and is under review by the Design Agencies to test alternatives to TCA in the final cleaning of plutonium. Some of alternatives under consideration are:

1. Water
2. Liquid carbon dioxide
3. A non-hazardous alternative solvent

Preliminary laboratory testing has shown each of these alternatives cleans plutonium and is compatible with this metal.(3)

Testing is also underway to identify alternatives to carbon tetrachloride as an "in process" cleaner and coolant in the plutonium manufacturing areas. The two alternatives showing the most promise are:

1. Dry machining plutonium instead of using oil and solvent
2. A non-hazardous alternative solvent

There will probably be a phased replacement of freon-113 in measuring the density of plutonium. The first phase will be the use of less-toxic chlorofluorocarbon (CFC) which is not restricted for land disposal under RCRA and not covered by the Montreal Protocol. The use of this CFC will continue until aqueous testing is complete and the use of water is approved by the Design Agencies. Table 4 shows projected reduction in plutonium-contaminated hazardous solvent waste.(4)

PAINTS, THINNERS AND PAINT STRIPPERS

A latex-based paint is now being used wherever an oil-based paint is not specified in the Plant Standards. These latex-based paints do not require organic thinners and are stripped using a caustic-based paint stripper instead of methylene chloride.

Since 1988 plant usage of oil-based paint has dropped approximately 80% and the use of methylene chloride-based paint stripper has dropped 30 gallons per year (12%). There isn't as much opportunity for reduction in methylene chloride stripper waste because Maintenance uses sand blasting whenever possible for stripping paint. The corresponding reduction on organic thinner waste has been from 600 gallons per year to 120 gallons per year (80%). These estimates are based on Maintenance Department records. The remaining oil-based paint use points and projected substitution with latex-based paints are shown in Table 5.

TABLE 5
OIL-BASED PAINT USE AT THE ROCKY FLATS PLANT

Description	Annual Use (1989)	Projected Reduction
Oil-based poly-amide floor paint	1000 gallons	Total elimination by 1991
Oil-based road stripping paint	800 gallons	Total elimination by August 1990
Co-polymer vinyls	500 gallons	200 gallons/year by 1991
Oil-based exterior	10% of all exterior paint	Evaluation of alternatives underway

RADIATION PROTECTION SHIELDING

Lead shielding has been used on gloveboxes and on tanks to reduce worker exposure to gamma radiation in plutonium areas. For the Plutonium Recovery Modification Project, Building 371, Health Physics is calculating the thickness of stainless steel that will replace lead in providing this protection.

The generation rate for waste lead shielding is 0.5 cubic meters per year.(5) This is based on Waste Operations data from January 1989 through October 1989. Although the generation rate of this waste form is low, there is currently no U.S DOE site permitted to dispose of this low-level radioactively contaminated mixed waste.

LIQUID FILTRATION

Wound polypropylene filters are used to recover or remove trace amounts of radioactive materials from a variety of liquid streams. These filters are called Fulflo^R and are standard cylindrical industrial cartridges, approximately 9.25 inches long and 2.5 inches in diameter.

The filters are placed in an in-line cartridge where the liquid flows through the filter until the buildup of filtered material increases the pressure and the filter must be changed.

A new filter is being developed which meets the following requirements:

1. Capable of being regenerated by backflusing, leaching, etc., for reuse.
2. Provide for one micron nominal filter capability.
3. Be inert to filterable liquids used at Rocky Flats.

4. Cost effective with regards to: initial cost, plutonium recovery cost, and waste treatment and disposal costs.

Kevlar fiber, a polymer of paraphenylene-diamine and terephthalic acid, was chosen as a material to investigate for the fabrication of a filter. Kevlar has excellent thermal and chemical resistance, does not shrink or melt, and has a degradation temperature around 500 C and incinerates clearly with about 1% ash.

The fabricated Kevlar filters have been evaluated with regards to: Filtering efficiency, flow rates, and pressure drop as a function of loading capacity in an nitric acid media. Test results show these filters are 90% more efficient than the polypropylene filters now in use. Similar tests have now started in an oil and solvent media.

Regeneration studies have not been successful using zinc oxide to simulate plutonium. Recovery of the zinc oxide was only successful by shredding the filter and centrifuging the shredded material. Plutonium testing is now planned to determine filtering efficiency and recoverability.

By crushing and dewatering the shredded Kevlar media, a 33% volume reduction can be achieved over the currently stored or discarded filters. There is a possibility of reducing the amount of transuranic filter waste generated by 100 drums per year based upon the non-radioactive filtering efficiency tests. This reduction would be a result of using fewer of the more efficient filters and then shredding and crushing the spent filters.

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Moving Beyond the Rhetoric:
Challenges for the 1990s

Kathryn S. Fuller, President
World Wildlife Fund and
The Conservation Foundation

International Conference on Pollution Prevention:
Clean Technologies and Clean Products
Omni Shoreham Hotel
Tuesday, June 12, 1990

Good afternoon. It is a pleasure to join you today for this first International Conference on Pollution Prevention.

Looking through your ambitious agenda for these several days, I'm struck by how far we've come in the past several years. We now see the logic of treating the source of our ailments, and not just the symptoms. The idea of preventing pollution--rather than collecting it, treating it, and shipping it from one place to another--is taking hold.

This conference itself--with speakers from government, industry, universities, environmental groups and other organizations--testifies to this evolution.

The Emergence of Pollution Prevention

Our new emphasis on pollution prevention makes sense for the reasons you have heard so persuasively already.

First, while we have made much progress over the past 20 years, in many areas we have been treading water, or have even lost ground.

Many of the countries represented here have made tremendous strides in controlling the pollution from industrial smokestacks, discharge pipes, and landfills. Nonetheless, we continue to lose ground. For example, we know that each new car in this country is cleaner than any model on the road twenty years ago. But the number of cars and the miles they are being driven are overwhelming our goals for pollution control. Half this country's natural endowment of wetlands has been lost, and 500,0000 acres of what remains are being consumed each year.

In the developing nations we are seeing wholesale destruction of tropical rainforests on a truly horrifying scale, only dimly imagined in 1970. As we meet, the tropical rainforests continue to be cut and burned at the rate of one percent per year--over 100,000 square kilometers each and every year.

Reliance on present approaches is not enough.

Second, many of the environmental problems we face today are of unprecedented complexity and scale.

As many as 100,000 chemical substances are used commercially around the world, and for many produced in very high volumes--10,000 metric tonnes or more annually--the public can get no toxicity data. In a long-needed step, the major manufacturing countries have just agreed to share the responsibility for getting toxicity information. The next step is a "sunset" and "sunrise" program. We need to "sunset" uses of chemicals already known to present hazards and encourage the "sunrise" of substitutes for these uses--in both the industrialized and developed world. Plainly, we can't wait until developing countries reach the state of some parts of Eastern Europe before we turn the focus of environmental policy to prevention.

We are just beginning to contend with global problems that were barely known not many years ago. The prospect of global warming and climate change ranks at the top. Assessing the prospects for climate change, Stephen Schneider says the possible three to five degree Celsius increase in the earth's surface temperature over the next 50 to 100 years "would be unprecedented in human history; it would match the five-degree warming since the peak of the last ice age...but would take effect between 10 and 100 times faster."

In the tropical forests, to cite E. O. Wilson, deforestation costs us 4,000 to 6,000 species per year--a rate of extinction "10,000 times greater than the naturally occurring background extinction rate that existed prior to the appearance of human beings."

These statistics give us reason for pessimism. But there are grounds, too, for encouragement--for pollution prevention has the promise of making good, economic and business sense.

Last week, we published an executive summary to a study which explores the costs of slowing climate change. Experts in eight industrialized nations were asked to evaluate the prospects for reducing fossil-fuel based carbon emissions in their respective countries, using the best economic models available to them. Their analysis demonstrates that many of the measures needed--such as improved energy efficiency--will actually strengthen economics rather than weaken them. By showing that we can act to preserve our biosphere without incurring enormous costs, this study helps save the way for more constructive policy debate on the benefits of pollution prevention.

We have only begun to see the fruits of the technological innovation that now leads industry in the direction of pollution reduction and improved economic efficiency. It was only recently that Vitronics, a new company in New Hampshire, first marketed a natural terpene derived from orange peels to substitute for chlorofluorocarbons in cleaning electronic circuitboards. This "sunrise" of a new product presents one business opportunity. Opportunities also come through using resources more efficiently. It is no coincidence that some of the most successful and profitable corporations see pollution prevention as the key to international competitiveness. Indeed, the potential for improved productivity may explain why many of you are here today.

Moving Beyond the Rhetoric

Accepting, then, that pollution prevention is the hallmark of future environmental policy, how does that translate beyond rhetoric into everyday practice?

First, we must clarify our goals and establish longer-term strategies.

That means a couple of things. All of us--whether we act in official capacities or as individual consumers--must be clear about our priorities and set up specific milestones to measure progress.

Within my own organization, we have just gone through a goal-setting process. It has been exhausting and exhilarating, but the result has been worth it. We have arrived at an intellectually sound, constructive set of principles--including the promotion of more efficient use of resources and energy and the maximum reduction of pollution--to guide our actions.

A little background might be in order. As some of you know, The Conservation Foundation was established four decades ago. It has built a reputation for independent policy analysis on many important issues: groundwater protection, wetlands conservation, agricultural pollution, public lands policy, risk assessment, integrated management of pollutants across different environmental media, and so on.

The U.S.-based World Wildlife Fund organization was created in the early 1960s by Russ Train--the first administrator of the Environmental Protection Agency. From the outset, it has focused on protecting endangered species and scientifically valuable habitats, principally through field work in Latin America, Africa and Asia. World Wildlife programs create parks and reserves, train local managers and build their capabilities, and support economic practices which are compatible with those natural resources.

Drawn this way, the two organizations look quite different. On the one hand, a policy research shop, focusing on domestic pollution and conservation issues. On the other, a nature-preservation group, focusing on direct delivery of field services outside the U.S. to protect biodiversity.

But in fact, we believe that the world has changed--that the environmental issues have evolved so that those distinct approaches must be brought to bear in a concerted way on common problems.

Let me illustrate. Just recently I was in Bhutan, a wonderful place, still two-thirds forested, reflecting the dual protections of a gentle Buddhist ethic and the nearly impenetrable Himalayan frontier. Yet when I followed the footsteps of the few thousand people who trek the mountains each year, I found the trails littered with discarded juice packs--the same boxes you buy at grocery stores here and tuck in your children's school lunches. The need for pollution prevention and recycling emerges even there.

More broadly, World Wildlife Fund has been remarkably successful in establishing parks and reserves for many critical habitats in the tropical rainforests of Latin America. But not far outside those parks and reserves are economies that increasingly produce toxic waste, airborne pollution, a growing demand for electricity--all the effects we associate with industrial society, all of them oblivious to park boundaries drawn on a map.

In many instances, the specific victories we have won in protecting a rare ecosystem can be quickly undone by these new threats. And so to protect nature, we must bring broader public policy skills to bear on pollution and the other problems of insensitive growth.

Conversely, the health of nature has much to tell us about pollution and human health. Last year, The Conservation Foundation completed a comprehensive study of the Great Lakes ecosystem, and the efforts by the U.S. and Canada to enhance that magnificent resource. Some of the things we found were disturbing: that Lake Superior, the least industrialized of the lakes, has serious problems from toxic contaminants blown in from cities and farms hundreds of miles away. That Great Lakes fish, birds and other species exhibit gross developmental defects, raising legitimate concern about human effects from exposure to the same substances.

In other words, we are learning that the quality of natural systems and the quality of human life--the nature conservation and pollution strains of environmentalism, if you will--are more intimately related than we knew.

In that context, we have merged World Wildlife Fund and The Conservation Foundation into a single institution. Together, we are part of a network of more than four million members in 28 national groups worldwide, working toward the conservation of nature by:

--protecting natural areas and wild populations of plants and animals;

--promoting sustainable approaches to the use of renewable natural resources; and

--promoting more efficient use of resources and energy and the maximum reduction of pollution.

This mission statement is not an end in itself. It is just the beginning of an ongoing process to lay out a system for measuring our progress and to change strategies when needed.

In the same way, we must reevaluate our laws, regulations, and institutions to see if they can deliver the progress we need so desperately today.

Our regulatory process has been designed to treat pollution at the end of the pipe, one medium at a time, though we now know that pollution respects no boundaries but often moves from air, to land, to water--even though its form may change.

Make no mistake. Pollution control and strong enforcement have played an important role in our achievements of the past 20 years and must continue to do so. But it would be a mistake to assume that these same institutions and decision-making structures will put effective meaning into the words "pollution prevention."

So where do we turn for a model for the future? One example at the state level is the Massachusetts Toxics Use Reduction Act. The result of a long process of negotiation, the law also aims at long-term change. It establishes reduction in use as the preferred means of complying with environmental and occupational health laws, and it sets a goal of 50 percent reduction in the amount of toxic wastes generated by 1997. Through a new system of environmental permits, Massachusetts seeks both to reduce the total waste entering the environment and to improve the efficiency of the permitting process for both companies and the government.

Put another way, pollution prevention means more than incremental change. For example, last year The Netherlands issued a national environmental policy plan--not separate plans for air, water, and waste--that includes measures to reduce sulfur dioxide and nitrogen oxide by 80 to 90 percent by the year 2010. (Our organization just published a book with the Institute for European Environmental Policy in London that includes a case study describing how this environmental policy plan evolved.) Last month, two Japanese companies, Isuzu and Fuji, announced that they have developed a supercapacity, rapid recharge battery that contains no mercury or lead at all. And a group of inventors and rubber scientists, working out of the old B.F. Goodrich plant in Akron, Ohio for the past five years, is now ready to market a high performance replacement for aerosol cans that uses no CFC's or volatile organic chemicals.

Now to reach such ambitious longer-term goals, we will need new and better strategies.

It is sometimes said that there are very few new ideas -- only a recycling of old ideas. Often what is called innovation is a concept used, and perhaps discarded, in the past. Certainly the term "pollution prevention" sounds familiar to the 3M officials who pioneered their now-famous Pollution Prevention Pays program in the 1970s.

True innovation or not, we must fashion a set of strategies for our changing circumstances.

Our new pollution prevention strategies will require us to look at the entire life of a product: the way we extract and process raw materials, how we manufacture and transport products to the market, how products are used and how they can be reused or recycled. As many of you know, various tools have been developed to analyze product life cycles. We need to examine whether these same tools remain appropriate today--for companies in selecting which products to sell, for government in setting its policies, and for consumers in choosing which products to purchase.

On a much broader scale, my organization has just embarked on a process to explore the fundamental changes needed in environmental policy. That process began two weeks ago with a roundtable discussion among former administrators of the Environmental Protection Agency, chairs of Council on Environmental Quality, and heads of state environmental agencies. All participants agreed that the time and conditions are right for us to identify new directions for environmental policy. We have laid out the kinds of issues to address with challenges to our traditional definitions of consumption and quality of life high on the list.

The third course of action involves each and every one of us. We must accept responsibility for our actions on a local as well as global scale.

Think of this frightening statistic. The United States, with 5% of the world's population, consumes 25% of the world's resources and generates approximately 25% of its waste. Now think of the resource implications were today's global population of 5 billion people to live as we do.

It doesn't take advanced mathematics to realize that the earth's resources couldn't possibly support that lifestyle. We all must change. And changes around the margins won't do. U.S. national policy must recognize its responsibility locally, and in world markets, for its role in polluting our environment. There are no long-run alternatives.

Likewise, businesses cannot use green technology selectively, and export old, dirty technology to developing markets. Rather than export mistakes from the past, we must seek to provide the best and most appropriate technology. In the longer term, we do ourselves no favors by sending outmoded or excessively technical or costly technology to countries whose pollution problems dwarf our own.

In their drive to develop and market clean technologies and products, businesses must also recognize that public sentiment for a cleaner environment cannot be taken for granted. Right now, public opinion polls show unprecedented levels of support for the environment. U.S. memberships in my organization are growing at a 30 percent annual rate--and remarkably, that lags behind the experience of World Wildlife Fund affiliates in other nations. Businesses are hurrying to meet consumer demand--for dolphin-safe tuna, recyclable containers, and a host of other "green" products.

But if we don't clearly and consistently define what we mean by clean products, we will see consumers increasingly confused about the choices they face, put off, and finally disenchanted. None of us can afford to let that happen. Businesses making investments to develop improved products can't afford to lose those consumers. Neither can the environment.

Individual organizations must also take responsibility for their office practices. My organization is currently doing just that, as I know many of yours are.

We are reevaluating products that we have purchased in the past, such as bleached paper, to find better alternatives. We are substituting reusable dinnerware at meetings and conferences for the disposable products we once used. I was pleased to see that the organizers of this conference, too, have made that a priority. And we are using products differently, by copying on both sides of paper, for example.

Sometimes the decisions we face are more complicated. World Wildlife offers a catalog of products including balloons, watches, and so forth. While it is one thing to make sure our paper products use recyclable material, it is quite another to decide whether or not the product itself serves as a symbol of unnecessary consumption in a world that can no longer afford to use resources wantonly.

And that brings me to the role we each play as individual consumers. Even now, when record numbers of people profess support for environmentalism, their actions suggest to the contrary. For example:

> --At a time of rising concern about toxic substances, Americans have made pesticide and herbicide treatment of their lawns a growth industry--as if Superfund and RCRA alone addressed all aspects of preventing toxic pollution. Will NaturaLawn, a company in Maryland, which specializes in lawn care to reduce pesticide and fertilizer use be able to lure us away? Given its rapid growth, perhaps so.
>
> --Everyone who buys a car is free to choose energy-efficient models, yet what have we gained if our lifestyles lead us to drive more and more miles with those same cars?

We each have a role to play in making prevention a reality in our daily lives.

In sum, these three courses of actions -- setting goals, finding new strategies, and taking responsibility for our actions -- converge in one overarching message: We must aggressively design policies that lessen the impact of economic activity on the environment.

Now, let me emphasize that environmental protection does not mean forgoing economic growth. Indeed a healthy environment depends on raising real standards of living around the world.

To prevent pollution we must absorb the costs of building more efficient factories and retrofitting existing ones, of producing and purchasing cleaner cars, of designing refrigerators that operate without CFC's. A vigorous economy helps businesses and consumers pay for those investments, and speeds up replacement of our existing capital stock with newer, more benign processes and equipment. Our policies should favor this investment, and we should strive to remove obstacles which retard the updating of our industries.

The message is even clearer in Eastern Europe. What we see as the Iron Curtain crumbles is nothing less than an environmental hell-hole: a huge zone of "acid blast" in East Germany, Poland and Czechoslovakia; poisoned cropland, sterile rivers; people forced indoors and even underground to escape the choking air. Here the answer is unmistakably capital investment and economic reform, to replace outdated, environmentally disastrous production systems on a national scale.

In the developing world, too, rising incomes are part of the solution.

I deplore the fires in Amazonia, and work hard to reverse the misguided policies that encourage this destruction: the subsidies and tax incentives that lead corporations to clear land for uneconomic farms and cattle ranches in Brazil. But much of the destruction is caused by desperately poor people who are struggling to eat and build rudimentary shelter for their families. They are driven by hunger, and guided by ignorance: they do not know that the soil will play out in a season or two, or that they are wasting priceless resources.

For these people, the answer is a better, more assured standard of living sustained by careful husbandry of the trees and indigenous species and crops. It means small, local sawmills, and roads so they can reach markets. It means banks where they can get credit for seeds and fertilizer. And it means basic education. Those are the changes that will turn people from miners of a resource into its stewards.

How, then, do we resolve the seeming conflict between increasing the standard of living for the world's poor and the pricing of natural resources more realistically? Certainly, developing countries, now exporting their natural wealth at unprecedented levels, will benefit from selling resources at higher prices.

But what about our own incomes and standard of living? Won't increasing resource prices reduce our incomes? The answer to that question is "not necessarily," if we define economics to encompass more than the dollars and cents of business transactions.

Economic analysis must also include measures of social welfare, of the quality of life. The price of cheap gasoline at the pump is no real measure of its price to society. Consider the waste from sprawling land use patterns which developed without regard to the full cost of fuel. Consider the obstacles to mass transit in cities mushrooming across the country. And consider the waste associated with artificial prices of the land and water themselves.

No, it is only through more accurate pricing--whether in the market place or in the form of strict regulation--that we will drive innovation in our technologies and products and maintain, even improve, our quality of life.

Concluding Thoughts: A Legacy for the Future

As I conclude, let me review where we've been and what I think it means for the future.

We are here today because we understand that a healthy environment requires preventive and not simply remedial action. We understand that pollution prevention is not just another implement in the toolbox of environmental reform. We understand that preventive policies reflect fundamental changes in resource use and economic behavior.

To meet these challenges, to make sure we move beyond rhetoric, we need to take strong actions: set priorities and find ways to change our institutions, devise appropriate strategies, assume responsibility for our own roles -- as consumers, employees, and heads of organizations and political states -- and redefine our understanding of economic costs.

The matter is urgent. If we view the history of our planet within the yardstick of just one year, our species has inhabited this world for only the last minute or so. All this accomplishment, and all this destruction, occurring in the last few minutes..of the last day..of that single year.

If I sound passionate about reinventing ways for humans to live on this planet, it is because I have indeed become so. And I would enjoin all of you to share in that passion. For it will take all our passion, commitment, and innovation to secure the most important of all gifts to the next millennium -- a planet on the mend.

Thank you.

Regulatory Impediments to the Reclamation and Reuse of Spent Potliner from Primary Aluminum Production

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In 1988, the U.S. Environmental Protection Agency (EPA) listed spent potliner, a byproduct of primary aluminum production, as a hazardous waste under provisions of the Resource Conservation and Recovery Act (RCRA). Many of the technologies utilized by the industry to reclaim and reuse spent potliner ceased as a result of the hazardous listing. This paper examines some of the regulations that serve as disincentives to recycling a byproduct, such as spent potliner, which has valuable energy and material values.

I. ALUMINUM REDUCTION AND SPENT POTLINER GENERATION

Aluminum metal is produced by the electrolytic reduction of aluminum oxide. The process takes place in a reduction cell, or pot, which consists of a strongly reinforced steel box or shell lined with heat insulation ("second cut material"), and prebaked carbon block and/or rammed monolithic carbon liner ("first cut material"). The steel shell, first and second cuts of the lining, and electrical conductors ("collector bars") . . . are collectively termed the "pot shell", which is used to contain the molten aluminum and electrolyte and conduct the electricity out of the pot (and therefore serves as the cathode). The anode is made of carbon. It is suspended over the pot shell by a superstructure that immerses it into the molten electrolyte. Electrolytic reduction cells are linked together electrically in series to form a potline, which may be housed in one or more buildings.

A pot can normally operate for five years; in several cases, up to ten years of operation have been reported. A pot "fails" when iron is detected in the molten aluminum, when cell voltage increases, or when the shell leaks molten metal or electrolyte. The iron contamination can be caused by the development of cracks or by erosion in the carbon lining, which allow electrolyte to come in contact with the steel collector bars or the steel shell. Comments of the Aluminum Association on the proposed relisting of spent potliner (January 2, 1986) ("Association Comments") at 76-80. Electrolyte is absorbed by the lining, which becomes saturated in the first 80 to 85 days of operation. When a pot fails, the lining is removed and the steel shell is relined. Id. at 76-83. The removed lining is called spent potliner.

II. REGULATORY BACKGROUND

EPA first addressed spent potliner under RCRA in 1979-1980, when it proposed and finalized a rule listing the material as a hazardous waste based on its cyanide content. However, both industry and EPA lacked complete, reliable information on the characteristics of spent potliner at that time.[1]

The 1980 regulation never took effect. On October 21, 1980, Congress enacted the Bevill Amendment to RCRA, codified at 42 U.S.C. §§ 6921(b)(3) and 6982(f),(d). The Bevill Amendment excludes from RCRA Subtitle C regulation "solid waste from the extraction, benefication, and processing of ores and minerals." EPA was directed to study these wastes and report the results to Congress before deciding whether to impose Subtitle C regulation under RCRA. On November 19, 1980, EPA interpreted the Bevill Amendment to exclude solid waste from the smelting and refining of ores and minerals, 45 Fed. Reg. 76,618 (1980), and withdrew the listing of spent potliner before its effective date. 46 Fed. Reg. 4614 (1981). EPA planned to study spent potliner as directed by the Bevill Amendment.

In October 1985, EPA proposed to reinterpret the term "processing" in the Bevill Amendment to apply to only "high volume, low hazard" wastes. 50 Fed. Reg. 40,292 (1985).[2] At the same time, the Agency proposed again to list spent potliner as hazardous, based on the assumption that the material was not "high volume" or "low hazard,"[3] and the assumption that spent potliner met the criteria for listing.[4] The proposal invited comments supplying new (i.e., post-1980) information about the hazards posed by spent potliner. Id. at 40,295.

In response to the proposal, the Association and its members filed substantial comments with EPA. The comments advised that data made available since 1980 show that as much as 60 percent of spent potliner does not contain cyanide levels that pose a threat to human health or the environment. The Association explained that the nonhazardous portions of spent potliner could be readily separated and removed from the pot. The Association's comments requested that alternatives to the proposed listing be considered, including defining spent potliner by reference to a threshold for free cyanide.

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[1] The background documents for the 1980 listing stated candidly that EPA "does not presently possess reliable data on iron cyanide concentrations in spent potliners themselves, but concludes that the concentrations of cyanide in potliners are substantial, based on cyanide concentrations in leachate from potliners." Background Document, Listing of Hazardous Wastes (Phase IB) at 278 (July 7, 1980). As of 1980, industry also lacked reliable data on the constituents of spent potliner.

[2] The 1985 proposal was in response to a lawsuit filed by environmental groups seeking to compel EPA to immediately regulate spent potliner as hazardous waste. The Court refused to grant this relief and instead put EPA on a rulemaking schedule. Concerned Citizens of Adamstown, et al. v. EPA, Civil Action No. 84-3041 (D.D.C. Mem. Op. Aug. 21, 1985).

[3] Industry data show that potliner is generated in substantial volume, approximately 120,000 metric tons annually. As will be seen, industry data also show that substantial portions of potliner are low hazard.

[4] In 1985, EPA had contracted with Radian Corporation to conduct a study of spent potliner . Radian analyzed data from 12 samples of spent potliner and potliner leachate. EPA relied on the Radian Report as support for its proposal to list spent potliner.

The Association's comments also pointed out that the proposed listing would subject all potliner management, including reuse and reclamation, to full Subtitle C regulation. The Association estimated that as much as 55 percent of all spent potliner currently was being reclaimed, and that the potential existed in the near term for reusing even more. The Association's comments stated that the proposed rule threatened to sharply reduce or eliminate potliner reuse and mandate landfilling the material. The Association identified 13 technologies -- either in commercial scale or actively being developed -- that were designed to capture the substantial energy and fluoride content of spent potliner.5/ The Association requested EPA to remove disincentives to spent potliner reclamation.

EPA's initial response to the Association's comments was to withdraw the proposed listing in October 1986 because of uncertainty about the scope of the Bevill Amendment. 51 Fed. Reg. 36,233 (1986). The Environmental Defense Fund and the Hazardous Waste Treatment Council filed suit challenging EPA's withdrawal of the proposed regulation. On July 29, 1988, the United States Court of Appeals ruled that spent potliner was not a Bevill waste and ordered EPA to list spent potliner by August 31, 1988. EDF v. EPA, 852 F.2d 1316, 1318, 1331 (D.C. Cir. 1988), cert. denied, 109 U.S. 1120 (1989). On September 13, 1988, EPA issued a rule listing spent aluminum potliner as hazardous waste under RCRA. The Association has filed a petition for review challenging the September 13, 1988 regulation. That petition is pending in the United States Court of Appeals for the District of Columbia Circuit.

III. THE REGULATORY IMPEDIMENTS

The present regulatory framework of the Resource Conservation and Recovery Act ("RCRA") has discouraged and in many cases eliminated the prospects for capturing the high energy and material value of spent potliner. Application of Subtitle C to byproducts of industrial operations -- including current rules defining solid waste, the mixture and derived-from rules, delisting procedures, and the storage prohibitions in the land disposal restrictions -- in some cases inhibits and discourages resource recovery. Instead, present rules virtually mandate costly, counterintuitive waste management, and in particular landfilling. Current regulations must be modified, preferably through a comprehensive, "holistic" approach designed to encourage resource recovery while controlling environmental risk.

Set forth below is a discussion of how the current RCRA regulatory framework inhibits the safe resource recovery of spent potliner, together with some proposed solutions. The discussion is divided by subject matter, though the issues raised are interdependent. They are: Classification and Delisting; Resource Recovery; and Storage.

5/ The technologies identified in the Association's comments were: cement kiln combustion, caustic leach cryolite recovery, basic oxygen steel furnace combustion, mineral wool furnace combustion, foundry cupola furnace combustion, lime kilns, sulfide roasting, recycling in Soderberg anodes, production of aluminum fluoride, pyrohydrolysis, pyrosulfolysis, reclamation in carbon linings, and fluidized bed combustion.

A. CLASSIFICATION AND DELISTING

1. Threshold Issue: Hazard Determination

a. The Problem

Substantial, segregable portions of spent potliner do not contain hazardous levels of cyanide, the Appendix VIII constituent which caused EPA to list spent potliner as hazardous waste under Section 3001 of RCRA. 53 Fed. Reg. 35,412 (1988). Data developed by industry in the last five years show there is wide, predictable variability in the cyanide content of spent potliner, depending upon its location within the pot shell. The primary aluminum industry has demonstrated that as much as 60 percent of the material is not hazardous and can be readily separated and safely handled without imposition of Subtitle C regulation.

The 1988 listing regulates all spent potliner. There is no threshold for cyanide in the listing. The Agency's efforts to ameliorate this recognized problem -- by "defining" the listing to exclude all insulation[6/] -- is, unfortunately, overbroad: It excludes material from the listing that contains significant levels of cyanide and continues to encompass material that does not contain cyanide levels of environmental concern.

b. Discussion

Using a protocol developed in conjunction with EPA, the Association submitted data on the characteristics of spent potliner to the Agency on April 16, 1986 and September 18, 1987. The data set was assembled from thirty-one pots and included three subsamples from each pot,[7/] for a total of 93 subsamples. The data show a high variability of free cyanide, covering four orders of magnitude. A significant number of samples do not exceed 20 mg/L. In fact, of the 93 subsamples taken, all 31 second cut samples, 26 of 31 bottom block carbon samples, and 17 of 31 side- and end-wall carbon samples were below 20 mg/L. The specific threshold proposed in 1986 was based on one hundred times the Public Health Service recommended level for cyanide of 0.2 mg/L. The attenuation factor is the same one used in the Toxicity Characteristic Leaching Procedure. 52 Fed. Reg. 29,993-94, 29997 (1987). In response to recent delisting petitions, EPA has used an even higher level of 0.7 ppm (equivalent to mg/L) instead of the Public Health Service level. See, e.g.,53 Fed. Reg. 36070, 36075, Table 4 (1988).

All samples passed the tests for volatile and semi-volatile organics and the hazardous waste characteristics, including extraction procedure metals and

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[6/] See Letter dated March 3, 1989 from Sylvia Lowrance to Jack Goldman.

[7/] Separate subsamples were taken from 1) side- and end-walls, 2) bottom block, and 3) insulation. Spent potliner is easily removable from the pot in these three segments. OSW staff witnessed "digging" a pot and separating its portions at a tour of Alumax's Mt. Holly, South Carolina facility on January 21, 1986.

reactivity.[8] Accordingly, based on free cyanide content and the hazardous waste characteristics, a significant proportion of spent potliner is not hazardous.

Thus, the Association proposed that second cut material not be included in the proposed listing and that first cut material be subjected to a characteristic test for free cyanide[9] as described in the protocol. Under this approach, industry estimated that over 75,000 tons of potliner per year would not warrant control as hazardous waste.

In an effort to accommodate the industry, the Director of OSW issued a letter on March 3, 1989 "clarifying" the scope of the listing. By that clarification, EPA takes the position that "thermal insulation composed of insulating brick or aluminum [sic.] [should be alumina]" is not considered to be "spent potliner." The Association has responded to EPA's clarification by noting that the clarified definition excludes from the scope of listing portions of material that contain significant levels of cyanide, and continues to regulate material that does not present a cyanide risk.

c. Proposal

EPA should amend the listing of spent potliner by:

i. Adopting a threshold level of free cyanide in the leachate, based on 100 times the drinking water standard so that material exhibiting concentrations of free cyanide below the threshold would not be hazardous waste;[10] and

ii. Refining its present definition of spent potliner to clarify that the insulation layer of spent potliner (refractory brick, alumina and/or insulating board) below the carbon bottom block, and refractory brick insulation behind the carbon side- and end-walls, is not part of the listing.

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[8] Because it is a solid, spent potliner does not exhibit the characteristics of ignitability or corrosivity. The April 1986 data set showed no failures for reactivity due to cyanide or sulfide concentrations. There were difficulties in achieving a pH of 2.0 in the reactivity test due to the buffering properties of spent potliner. However, if the pH-adjusting step had been modified to achieve a pH of 2.0, it appears that all samples would have passed. The September 1987 data set did not analyze for reactivity or organics.

[9] The Association explained in its comments that measurement of free cyanide, rather than total cyanide, should be the regulatory trigger. Association Comments at 129-31. Cyanide complexes in spent potliner do not readily degrade.

[10] The Association's November 9, 1988 letter to EPA (see note 7 supra) proposed a specific test method and an attenuation factor for development of the threshold.

2. Mixture and Derived-From Rules

a. The Problem

Application of the mixture and derived-from rules also discourages resource recovery. Under the derived-from rule, 40 C.F.R. 261.3(c)(2)(i), all residue from treating a hazardous waste is itself hazardous until and unless it is delisted. For example, all ash from combusting spent potliner in a reclamation process is presumed hazardous.

In addition, the mixture rule, 40 C.F.R. 261.3(a)(2)(iii), defines as hazardous the entire mixture of a hazardous and solid waste. So if potliner is mixed with a nonhazardous solid waste, the entire mixture is considered hazardous because of the complex cyanide content of the listed waste, spent potliner. In addition, the current delisting mechanism (see below) is not an adequate solution to the deregulation of residues.

When the two rules are both applied to spent potliner reuse and reclamation, the incentive for independent facilities to process the material is virtually destroyed. For example, a coal-fired electricity generator could replace 0.5% of its feed with spent potliner. However, because the derived-from rule renders spent potliner ash hazardous, and the mixture rule renders all of the coal-derived ash hazardous when mixed with the small volume of spent potliner ash the facility would now have to comply with all hazardous waste regulations. There is simply no incentive to do so. The situation is repeated, in one degree or another, in all reclamation and reuse processes available to spent potliner.

b. The Solution

Application of the rule must be modified on a case-by-case basis to facilitate resource recovery. In place of the derived-from rule, a de minimis level must be established for the constituent of concern. When the residue from processing is produced, it is not presumed hazardous, but must be tested for levels of the constituent. If the de minimis levels are exceeded, the residue is hazardous.

Exceptions to the mixture rule must be considered on a case-by-case basis, so that the EPA's prohibition of dilution is not abrogated.

3. Delisting

When spent potliner was listed as a hazardous waste, EPA officials expressed hope that the delisting process would be a vehicle for addressing the industry's concerns of over regulation. Unfortunately, the present delisting mechanism does not work well for spent potliner.

a. The Problem

A problem with the current approach to delisting is the failure to integrate exposure assessments into the process. Although delisting petitions must be prepared by generators on a facility-by-facility basis, the present reliance on generic, risk-based constituent levels does not account for exposure potential. Exposure potential is a key determinant of environmental risk.

A second, compounding problem is the cumbersome nature of the delisting mechanism and the concomitant uncertainty over whether a permit will be obtained.

b. Discussion

The delisting process does not permit site-specific risk evaluations, viz., determinations of acceptable risk based on an assessment of both exposure and toxicity potential of management practices utilized at particular receiving sites.[11] It is axiomatic that risk assessments are site-specific and that baseline risk can be determined only after summarizing and combining outputs of exposure and toxicity.[12] Current procedures require a petitioner to prove -- regardless of exposure potential -- that the waste or residue does not meet any of the criteria for which it was listed (40 C.F.R. § 260.22(a)(1)), and that factors (including additional constituents) other than those for which the waste was listed cannot cause the waste to be hazardous (id. § 260.22(a)(2)).

c. Proposal

Several steps should be taken to make the delisting process more effective. First is to permit site-specific risk assessments based on evaluations of toxicity and potential exposure. A generator should be allowed to delist a waste or residue at the site of generation and at the facility or facilities where the waste will be processed, based on an evaluation of toxicity and exposure potential at the site. A generator would be required to cértify that the waste will be managed in a certain way and that failure to adhere to all specified conditions would result in the waste being subject to full Subtitle C regulation.

Second, EPA should streamline the delisting process by defining the universe of information that is relevant for a particular waste. The establishment of threshold limits for specific hazardous constituents would make the delisting procedures more effective and less cumbersome. To facilitate these proposals, a guidance document should be developed for spent potliner delisting petitions.

B. RESOURCE RECOVERY

1. The Problem

The rules defining "solid waste" discourage reuse of spent potliner for energy recovery. Present rules subject virtually all burning of hazardous waste for energy recovery to Subtitle C. A further impediment to capturing energy and material value from spent potliner is the Agency's view that a material is "inherently waste-like" if it contains Appendix VIII constituents not ordinarily found in material substitutes and which are not used or reused in the process. See 40 C.F.R. § 261.2(b)(2), (c)(2), (d)(2).

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[11] Apparently, EPA has concluded that the Agency lacks control over how a waste will be managed after delisting and thus believes that it is inappropriate to consider site-specific factors. See, e.g., 53 Fed. Reg. 50551 (1988).

[12] See, e.g., Risk Assessment Guidance for Superfund, Vol. 1, Human Health Evaluation Manual (Part A) at 1-6, 1-7 (December 1989).

Spent potliner has substantial energy and material value which can and should be utilized. Cyanide, the constituent for which spent potliner is listed, is destroyed in a variety of heat recovery processes. Other constituents in spent potliner are commercially valuable and used beneficially. Combustion of spent potliner for energy recovery should not be discouraged simply because it is burned or because cyanide is not "reused" in the process.

2. Discussion

Congress enacted RCRA "to promote the protection of health and the environment and to conserve valuable material and energy resources." 42 U.S.C. § 6902. In an effort to comply with this statutory mandate, EPA has promulgated regulatory controls to govern resource recovery. Unfortunately, these regulatory controls have made resource recovery very difficult, if not impossible, in many cases.

Under existing regulations, virtually all burning of hazardous waste for energy recovery is subject to Subtitle C regulation.13/ EPA has taken the position that a material is "inherently waste-like" if it contains Appendix VIII constituents that are not ordinarily found in material substitutes and that are not used or reused in the process. The reuse of spent potliner as a fuel or material substitute should be considered legitimate recycling. The fact that the constituent for which spent potliner was listed as a hazardous waste (i.e., cyanide) is not recovered in these processes should be no barrier to reduced regulation. Cyanide is destroyed in these energy recovery processes and is not, therefore, released into the environment.14/ In addition, fluoride and other constituents in spent potliner are commercially valuable and are used beneficially and safely in these recovery processes.

3. Proposal

Spent potliner that is processed for energy or material recovery should not be presumptively characterized as hazardous waste treatment. If there is significant material recovery or if the Btu content is substantial and hazardous constituents in the material are destroyed or rendered nonhazardous in the resource recovery process, then the material should not be a solid waste for regulatory purposes. Qualifying material would, instead, be subject to special rules for tracking, storage, performance standards for resource recovery, and for testing residues for hazardousness.

13/ The proposed burning and blending rules contain an exemption for burning "indigenous" listed hazardous wastes in industrial furnaces. The exemption suspends application of the derived-from and mixture rules for qualifying furnaces. 54 Fed. Reg. 43,718 (1989). The proposed exemption would not provide any relief for spent potliner because it is not indigenous to the furnaces in which it has been successfully burned, e.g. mineral wool and cement kilns.

14/ The Association has submitted extensive data to EPA showing that cyanide is destroyed to the limit of detection levels in several processes.

C. STORAGE

1. The Problem

Spent potliner can be safely stored prior to reuse or treatment. Current regulations appear to preclude storing spent potliner without a permit for up to 90 days and in any manner once BDAT rules go into effect. The aluminum industry needs to store spent potliner prior to resource recovery because of batch generation, volumes, and distances involved.

2. Discussion

Materials regulated as hazardous waste can be stored at the site of generation for up to ninety days without a permit, provided that the materials are stored in tanks or containers. 40 C.F.R. § 262.34. Spent potliner is generally stored in buildings designed to prevent exposure to the environment. These buildings typically have concrete floors and are enclosed, thereby preventing exposure to precipitation and the risk of hazardous constituent run-off into the environment. Storage in such buildings for up to 90 days without a permit is safe. Unless these buildings are considered "tanks" under present regulations, the aluminum industry would be required to obtain a permit for storage of less than ninety days.

In addition, present regulations implementing the land disposal restrictions under RCRA would prohibit any storage of spent potliner in buildings prior to processing once BDAT standards are developed for the material.[15/] Current regulations flatly prohibit storage other than in tanks or containers once BDAT is established. 40 C.F.R. § 268.50(a). Accordingly, all storage of spent potliner prior to processing would be prohibited.[16/]

These regulations must be modified. The buildings in which spent potliner is stored meet the performance requirements of 40 C.F.R. § 264.250(c), which excludes certain waste piles in buildings from leachate collection and liner requirements as well as groundwater monitoring provisions provided that: 1) liquids or materials containing liquids are not placed in the pile; 2) the pile is protected from surface water run-on; 3) the pile is designed and operated to control dispersal of the waste by wind; and 4) the pile will not generate leachate. Aluminum industry management

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[15/] EPA is expected to promulgate land disposal BDAT standards for spent potliner in 1991 or 1992.

[16/] This result appears not to comport with the Agency's intent. The preamble to the land disposal restrictions for the third-third rule recognizes that the prohibition against storage may be too broad. EPA has acknowledged that "[t]he intent of RCRA section 3004(j) and 40 CFR 268.50 is to prohibit use of long-term storage to circumvent treatment requirements imposed by the land disposal restrictions." 54 Fed. Reg. 48,372, 48,496 (1989). With spent potliner, the storage prohibition should not apply because it is not surrogate disposal, or otherwise undertaken for purposes of evading a land disposal prohibition. The Association made this comment to EPA on January 8, 1990.

practices, including the buildings used to store spent potliner, fully meet these requirements.

3. Proposal

The aluminum industry has designed and built structures meeting the performance requirements of 40 C.F.R. § 264.250(c) and which can be used to safely store spent potliner and ensure protection of the environment. The 90-day storage exemption and the exception from land disposal restrictions for temporary storage must be modified to include such buildings.

IV. CONCLUSIONS

While the list of impediments just discussed may not be exhaustive, it represents a set of major regulations that impede the reclamation and reuse of spent potliner. As mentioned earlier, the list is interdependent, and solution of several of the problems would break the logjam and allow the aluminum industry to use spent potliner beneficially.

It should also be noted that the approaches outlined in this paper attempt to ease the regulatory burden while maintaining environmentally safe processing. The key is to focus regulatory requirements on the material being processed; the use of generic requirements to guard against all possible worst cases of all wastes causes beneficial materials such as spent potliner to be land disposed.

The problem of disincentives to industrial waste reclamation and reuse is finally being recognized by the administrative branch, Congress, and even the environmentalists. It is hoped that, through discussion, the major disincentives can be eliminated in the next few years.

RECLAIMING FIBER FROM NEWSPRINT BY DRY METHODS

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INTRODUCTION

United States publishers presently use 40% of the total world consumption of newsprint (more than 12 million tons annually); 57% is imported from Canada, and another 1% to 2% is imported from Scandinavia. The cost of these imports is about $5 billion annually (*1,2*). At present, old newspapers (ONP) represent both a serious solid-waste problem and a valuable resource (*3–6*). Although approximately one-third of all newspapers printed are recycled, ONP still accounts for almost 7% of the solid-waste landfill burden (*3–5*). Legislation requiring the recycling of ONP has been enacted in several states, and literally hundreds of bills are being considered in other states and municipalities (*6*).

With the continuing improvement of deinking and secondary fiber recovery systems, a natural market for ONP lies in the manufacture of newsprint. Innovative papermakers around the world have demonstrated that significant fractions of ONP can be used in newsprint with acceptable results using existing technology (*7–10*). Impediments to broad adoption of this approach are (a) the high cost of backshipping ONP to newsprint mills, often located many hundreds of miles from the urban source of the ONP (*11*), and (b) the large capital investment and massive water demands inherent in converting ONP to newsprint by conventional means. Water demand is not a problem at the present sites of virgin newsprint mills, but it is a serious limitation to urban siting of recycle mills. If we could choose the best of all worlds, we would convert ONP to newsprint in urban areas using "mini-mill" processes involving little or no net demand for water and simple, low-cost machinery. Given the need, one is almost compelled to ask, "Is there any reality in such an attractive fantasy?"

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The purpose of our research is to explore this conceptual territory. Specifically, our objective is two-fold; first, to explore (bench-scale) methods for liberating fiber from ONP with minimal use of water and with minimal damage to the fiber, and second, to explore papermaking techniques that would yield an acceptable newsprint using less water than do current methods, based on machinery that is less costly to purchase and operate than current machinery. Deinking is not a part of this study. Our research is funded by the American Newspaper Publishers Association (originators of the mini-mill concept), the Environmental Protection Agency, and the USDA Forest Service. All participants recognize the risk associated with a radical departure from established, effective methods—particularly in a mature industry. Yet, contemporary resource changes and societal needs to reduce landfill waste argue the merits of another look at alternatives—risky or not (*12*).

In this paper, we report three experiments; two are related to mechanical fiberizing of dry or semidry newsprint, and the third describes progress in the production of a newsprint-weight handsheet by an air-forming technique. These experiments describe what we have observed on the "road not taken" in prior developments. The work has not been highly successful, but concepts and processes that may make urban conversion of ONP to newsprint not only feasible but highly attractive may yet exist.

EXPERIMENTS AND RESULTS

Screening Test for Fiberizing Methods

The purpose of this initial experiment was to find a combination of machine type, feed source, and operating conditions that would be successful in liberating individual fibers for use as a furnish in subsequent forming of newsprint sheets. The ONP source (for the screening test and all experiments reported here) was a clean, never-printed, stub roll of virgin spruce furnish—75% groundwood and 25% chemithermomechanical pulp (CTMP). This stock entered the fiberizing process as either strips (cut to 75 by 500 mm) or "crumbs." Crumbs were prepared by hydropulping the roll stock, followed by bulk dewatering in a screw press, shredding, and drying to various moisture contents. The crumb pulp is intended to represent output of a wet-deink process. Moisture contents from 4% to 60% are to be anticipated.

Based on our own earlier attempts with a variety of devices and on the experience of others (*13*), we selected three machines with very different actions for the first set of controlled fiberizing experiments. We hoped to generate a range of products that would point toward effective fiberizing concepts as opposed to optimizing a set of operating parameters. The machines were as follows:

1. A laboratory 200-mm single-disk atmospheric refiner with three blade sets of various design. The refiner is powered by a 3.7-kW motor at 3,600 rpm. Blade gaps ranging from 0.05 to 1.25 mm were investigated.

2. A 260-mm-diameter commercial hammermill in which a large number of articulated blades impact and abrade the furnish between the blade and a perforated screen. The blades rotate at 4,000 rpm; hole sizes of 3 mm and 1.5 mm were investigated.

3. A commercial, variable-speed "deaglomerator" in which a single rotating impeller propells the furnish at high speed within a perforated basket. Particle size is reduced by repeated impact of the furnish against the basket surface until the furnish passes through the perforations. Impeller speeds are variable from 0 to 4,200 rpm. We selected hole patterns of 0.8 mm diameter, 28% open area, and 1.9 mm diameter, 51% open area; impeller speed was 900 rpm.

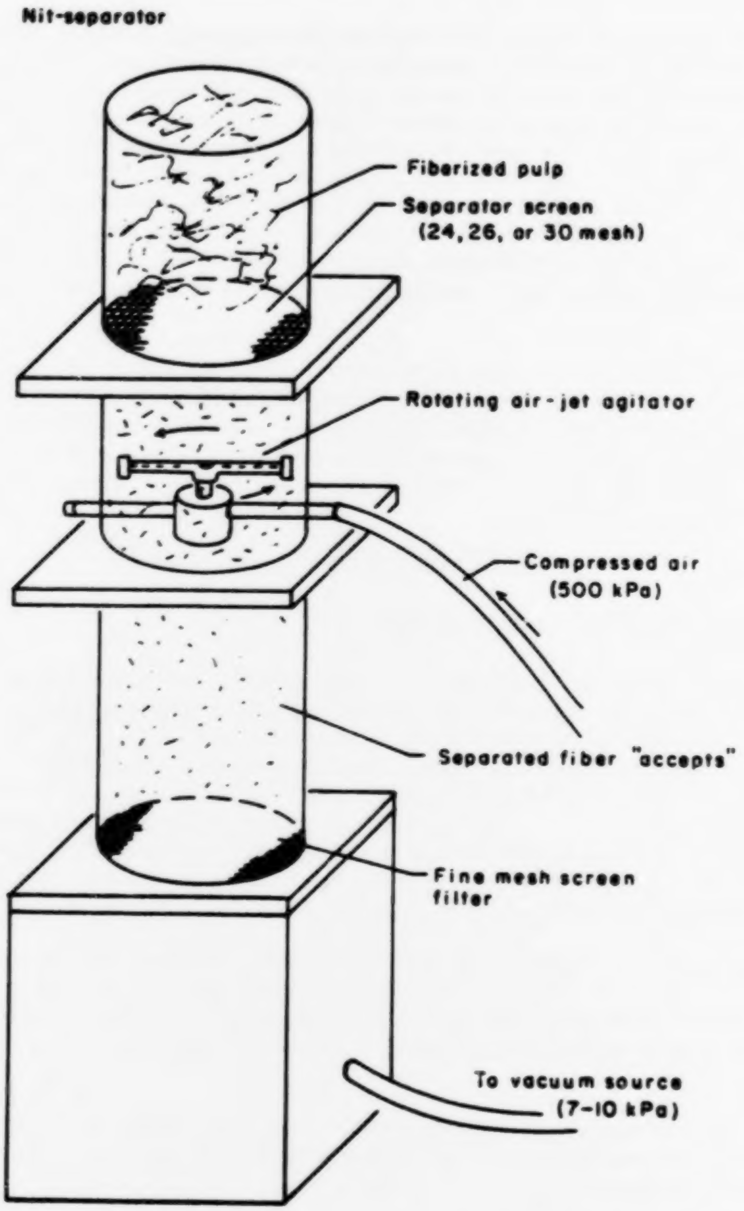
Nit-separator
Fiberized pulp
Separator screen (24, 26, or 30 mesh)
Rotating air-jet agitator
Compressed air (500 kPa)
Separated fiber "accepts"
Fine mesh screen filter
To vacuum source (7-10 kPa)

Figure 1. FPL-designed nit separator. Fiber fluff is agitated by air jets to separate individual fibers from paper fragments and fiber bundles.

We were able to find a range of operating conditions for each of the three machines that produced a fiber fluff containing a high proportion of individual fibers. This fiber was generally mixed with paper fragments or fiber bundles, which we have called nits. To determine the yield of individual fibers and to separate fiber from nits for sheetmaking, the fluff must be screened or classified. We developed the apparatus depicted in Figure 1 for this purpose.

TABLE 1. SELECTED SCREENING TRIALS OF FIBERIZING METHODS

Fiberizing method	Feedstock	Moisture content (%)	Separator yield (%)	Fiber length* (mm)
56–Control+			100	1.26
75–Disk refiner #1 blade	Crumb	18	100	1.20
74–Disk refiner #1 blade	Crumb	18	72	1.20
71–Disk refiner #1 blade	Strip	16	82	1.18
72–Disk refiner #1 blade	Strip	16	100	1.18
50–Hammermill 3.0-mm holes	Strip	8	50	1.15
76–Disk refiner #3 blade	Crumb	18	69	1.02
52–Deaglomerator 0.8l-mm holes	Crumb	4	98	1.00
77–Disk refiner #3 blade	Strip	7	75	0.97
78–Disk refiner #3 blade	Strip	16	71	0.96
80–Disk refiner #3 blade	Crumb	4	81	0.90
73–Disk refiner #1 blade	Crumb	4	88	0.88
70–Disk refiner #1 blade	Strip	7	92	0.84

*Weighted fiber length determined by Kajaani FS–100.
+Furnish disintegrated in hot water.

Our initial measure of the quality of pulp obtained from disintegration and separation processes was the fiber length distribution of accepts as measured by a Kajaani FS–100 fiber length analyzer[1] (*14*). The Kajaani instrument employs a narrow capillary tube that allows single fibers to pass through. It optically measures the length of each fiber in a very dilute sample composed of thousands of fibers. After a sample has been run, the instrument calculates distribution of fiber lengths and a weighted-fiber-length average in millimeters. Reduction in the percentage of long fiber in the furnish (seen as reduced weighted fiber length) is direct evidence of fiber damage in the fiberization process and predicts degradation in mechanical properties of handsheets (*15–18*).

Table 1 cites the operating conditions, yield, and weighted fiber length for the most successful 12 of 20 initial mechanical fiberizing trials and for the control (furnish disintegrated by gentle agitation in hot water (85°C)). Feed rate for all fiberizing processes exclusive of control and for the hammermill was approximately 50 g/min. The hammermill was fed at approximately five times that rate. Blade gap setting for all disk refiner trials reported in Table 1 was 0.13 mm. The table is arranged in order of decreasing resultant fiber length and shows a variety of yields ranging from 50% to 100%. In this experiment, the strong differentiation relating to machine type that we had anticipated did not occur.

Given the undifferentiated response from machine to machine and the ease of use, flexibility, and range of results obtained from the disk refiner, we have used the disk refiner almost exclusively for subsequent processing experiments. The high nit content of low-yield processes was apparent to the eye, but differences in fiber length were not. All high-yield products appeared equally good. The data suggest a tendency toward better fiber length retention for higher moisture content furnish. The most significant finding of this work is that either crumb or strip furnish can be mechanically fiberized with good yield and little loss of fiber length.

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[1] The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.

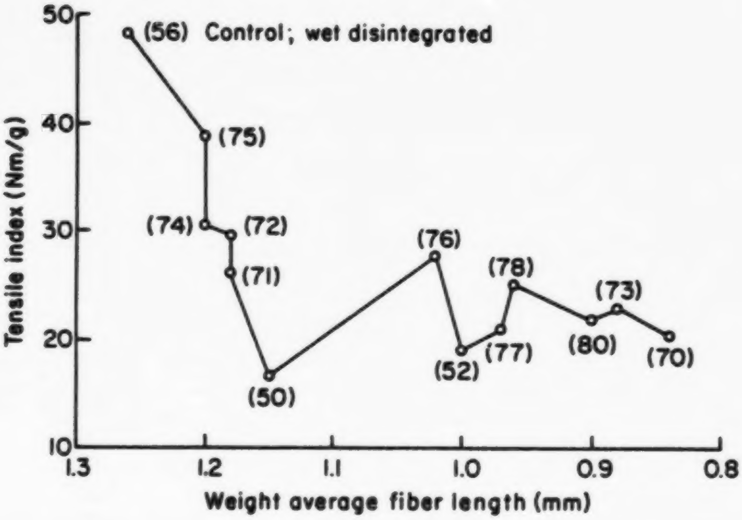

Figure 2. Tensile index of TAPPI water-laid/press-dried handsheets made from fiber obtained in selected dry-fiberization processes. Fiber length measured by Kajaani FS–100. Numbers in parentheses correspond to fiberizing methods (Table 1).

In the second phase of this experiment, fiber produced by the various means was formed into handsheets by the wet process described in the Technical Association of the Pulp and Paper Industry (TAPPI) Standard T205, press dried in accordance with methods described by Horn (*19*) at 135°C at 700 kPa, and evaluated for tensile strength and tear resistance according to TAPPI methods T494 and T414, respectively. Figure 2 shows tensile strength index as a function of the weighted fiber length measured for the various methods. (Tensile index represents force per unit of specimen width per gram of fiber.) The highest strength value, at 1.26 mm weighted fiber length, is that for the control fiber liberated by gentle agitation in water. Results show the tensile index dropping 46% as fiber length declines 7% from 1.26 to 1.18 mm. Reductions in fiber length below 1.18 mm show a less pronounced effect.

Barring a unique sensitivity to small initial reductions in fiber length, the results suggest a difference in the mechanically liberated fiber that compromises sheet tensile strength. Handsheets made from mechanically liberated fiber at fiber lengths of 1.20 mm and 0.88 mm had low strength, strain-to-failure, and tear index values compared to handsheets made from control pulp and virgin roll stock (Table 2). The clearly superior performance of the fiber processed at 18 percent moisture content compared with that of fiber processed at 4 percent moisture content suggests the potential for better results in fiber processed at still higher moisture content. The control pulp handsheets had higher strength properties than did the sheets from the roll stock as a result of the greater density and strength-enhancing qualities of press drying (*20–22*).

Effect of Moisture Content on Fiber Length and Handsheet Strength

We evaluated handsheets made by different fiberizing methods over a range of moisture contents from "as pressed" at 67% moisture content to ovendry at less than 4% moisture content. Quantities of crumb furnish were tumbled at 50°C in a commercial drum-type dryer to obtain intermediate values of 52.5%, 42.5%, and 31% moisture content (as well as ovendry). These

TABLE 2. STRENGTH PROPERTIES OF NEWSPRINT AND RECYCLED WATER-LAID HANDSHEETS

Material	Fiber length[*] (mm)	Density (kg/m)	Tensile index[+] (nm/g)	Strain to failure[+] (%)	Relative tear index[+,#] (mN×m/g)
Roll stock	—	640	39.0	1.37	120
Control pulp[†]	1.26	776	48.2	1.42	100
Disk refined pulp[†]					
18% moisture content	1.20	630	38.8	0.73	91
4% moisture content	0.88	700	22.9	0.48	52

[*] Weighted fiber length determined by Kajaani FS–100.

[+] Geometric mean of machine-direction and cross-machine-direction properties.

[#] Expressed as percentage of control.

[†] TAPPI water-laid handsheets, press dried at 135°C, 700 kPa.

furnishes were subsequently fiberized in the single-disk refiner using blade set 1 at a clearance of 0.13 mm. (Crumbs at 67% moisture content would not fiberize but tended to stick to blade surfaces in the refiner, which eventually stalled the motor.) A control pulp was prepared by hydropulping roll stock in water at 20°C. The relative fiber length of the pulps mechanically fiberized at various moisture contents are shown in Figure 3. Increasing moisture content was clearly beneficial in promoting retention of fiber length; disk-refined fiber at 52.5% moisture content retained 97% of the length of the control fiber. The control pulp and the four pulps produced at ovendry to 52.5% moisture content were then formed into handsheets by TAPPI method T 205, as in the previous experiment, and press dried at 135°C, 700 kPa. Because of the high yield in this process, nits were included in the test sheets with no apparent effect.

Handsheets were evaluated for tear strength, tensile strength, stiffness, strain to failure, and energy absorption. Results for the four disk-refined pulps are shown in Table 3. The tear resistance for the best of our mechanically fiberized pulps was 93% of that for the control pulp. Tear strength tends to decline for the other pulps as fiber length decreases (*15,16,18*). Strain-to-failure and tensile strength followed a similar pattern, but the highest value of each was limited to approximately 70% of that for the control pulp. Tensile energy absorption was 46% of the control for our best pulp, and it dropped to 25% of the control for the fiber produced at ovendry conditions. We conclude that although we have been successful in liberating fiber from crumbs at 52% moisture content with almost no loss of fiber length, we have not yet produced a fiber that can replicate the performance of the control furnish in terms of sheet strength or toughness.

Web Formation

This experiment explored air-forming methods as an alternate means of web formation. The objective was to determine if the net demand for water in the recycling process can be reduced by use of forming means other than conventional wet-forming, which occurs at water to fiber ratios of 100:1 and higher (<1% consistency). It has long been known that webs with excellent formation can be made by air deposition of fiber at low moisture content (air-laid webs) (*13,23*). These webs can be wetted with water and then dried under restraint to create hydrogen bonding between the fibers. The strength of sheets produced in this way has characteristically

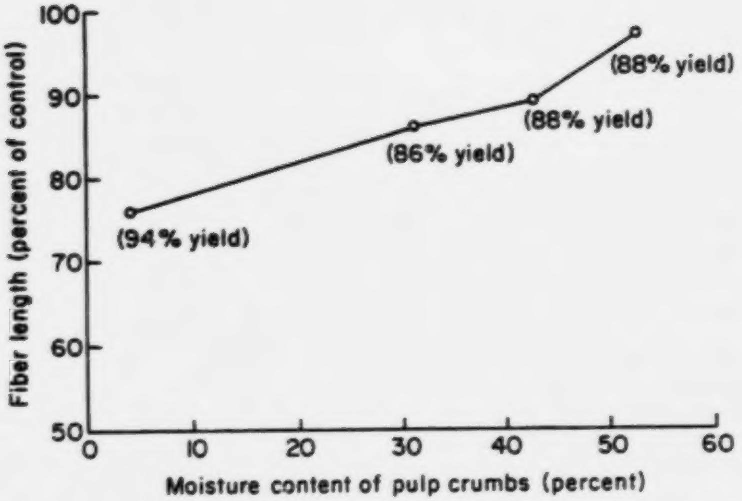

Figure 3. Relative fiber length of pulps fiberized at various moisture contents in single-disk refiner. Reference is water-disintegrated control pulp. Numbers in parentheses specify separator yield.

TABLE 3. EFFECT OF PROCESSING MOISTURE CONTENT ON FIBER LENGTH AND HANDSHEET PROPERTIES

		Handsheet properties (%)*				
Moisture content (%)	Fiber length (mm)	Tensile strength	Stiffness	Strain to failure	Energy absorption	Tear
52.5	97	69	79	70	46	93
42.5	89	59	67	60	33	72
31.0	86	63	77	71	44	79
4.0	76	57	76	48	25	43

*Shown as percentage of control handsheet values. TAPPI water-laid handsheets, press dried at 135°C, 700 kPa.

been less than that of sheets produced from water-laid webs. However, with the development of press-drying technology and its demonstrated ability to enhance the strength of webs with poor natural bonding potential (*20–22*), it is reasonable to ask if the combination of air-laid web formation and press drying can yield a recycled newsprint of acceptable strength (*24*).

Air-Forming and Water-Forming Methods

For this evaluation, a quantity of pulp was dry fiberized from crumbs at 25% moisture content in the disk refiner using Method 75 (see Table 1). With this fiber, we then formed a series of air-laid and water-laid handsheets varying the temperature of the forming or rewetting water, the forming substrate, and, because press-dry effectiveness has been shown to vary with sheet weight, the grammage. Our results showed the forming substrate for the air-laid webs had

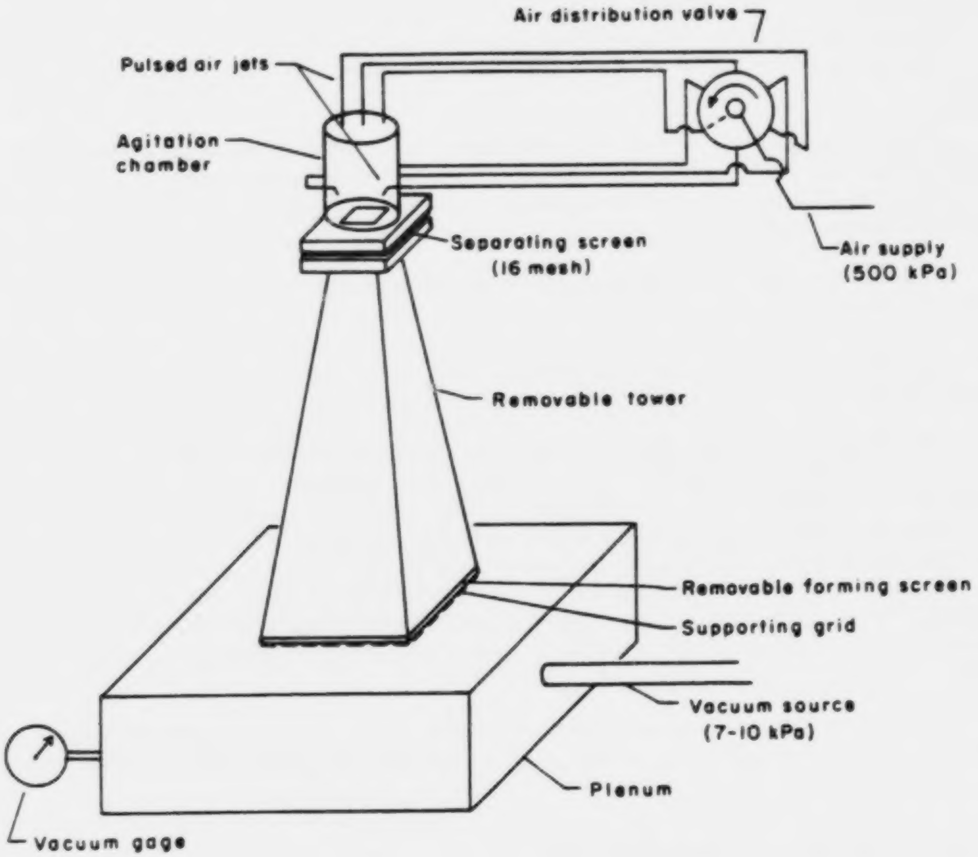

Figure 4. Forming apparatus for handsheets. Fiber liberated in agitation chamber is drawn through 16-mesh screen and deposited to form web on removable forming screen.

little effect on the outcome of the experiment. To simplify presentation, we report only four procedures that span the range of results: two water-laid methods and the best and worst of the air-laid methods.

Air-laid handsheets were made in an apparatus designed by the Forest Products Laboratory (Fig. 4). The fiber for one sheet is placed into the agitation chamber and the top of the chamber is sealed. A 7- to 10-kPa vacuum is applied to the plenum by an industrial vacuum source. The air jets are then alternately pressurized by 500 kPa compressed air, causing the fiber bundles to agitate and the individual fibers to shake loose from each other. As the fibers are separated, air flow carries them through the 16-mesh screen and down through the tower. The forming screen at the bottom of the tower retains the fiber as the air passes through creating a uniform web of fibers. The process takes approximately 1 min. The web is then removed with the forming screen for rewetting and drying. In this experiment, webs were formed at 50, 70, and 90 g/m^2.

The rewetting procedure was found to be a significant variable for air-laid webs. Air-laid handsheets wetted with cold water were rewet by placing the web, on its forming screen, onto a plastic grid in a shallow pan. The water level in the pan was just slightly above the top of the grid. The water was able to soak up into the web through the forming screen by capillary action. The water temperature was 19°C; wetting time was approximately 1 min. Once wetted, the web was wet pressed between blotters at 3.0 MPa and subsequently press dried at 149°C, 3.0 MPa for 1 min.

Air-laid handsheets wetted with hot water were treated in the same manner as handsheets wetted with cold water except that the temperature of the rewetting water was 55°C. After rewetting, the web was held in a saturated environment at 38°C for 1 h to ensure thorough wetting of the fiber prior to wet pressing and press drying.

The temperature of the forming water was a significant variable in the performance of water-laid sheets (formed in a British sheet mold). To form cold-water-laid sheets, fiber for one sheet was mixed in 19°C water for 15 s. The slurry was then added to the sheet mold, diluted with more 19°C water, and drained to form the web. Webs were couched off the screen, wet pressed between blotters in groups of six, and press dried.

Hot-water-laid sheets were made in similar manner, but fiber preparation was modified in a manner intended to enhance fiber flexibility and remove latency (*25*) prior to forming. Fiber for six sheets was weighed out and mixed in 55°C water for 15 min. After the fiber was mixed, the fiber slurry was added to a doler tank and diluted with more 55°C water. The fiber was allowed to mix in the doler tank for an additional 45 min before forming, wet pressing, and press drying. The overall formation and appearance of the better air-laid and water-laid sheets were good to excellent. However, the air-laid sheets were subjectively inferior to the water-laid sheets in their appearance and characteristically exhibited a small number of pinholes not seen in the water-laid sheets.

Density and tensile strength results are shown in Figure 5. The data show the superior performance of water-laid webs and the beneficial effect of hot water (and extended sorption time) relative to cold water.

Air-Forming and Liquid-Forming Methods

Another experiment provided a better understanding of the significant difference in performance of the webs made by air-forming as opposed to liquid-forming methods. The orientation and networking of fibers in an air-laid web is presumably different from that in a liquid-laid web. It is reasonable to ask if the reduced performance of air-laid webs is related to such differences in web structure. In this experiment, dry fibers were air laid, using methods previously described, or liquid laid, using ethyl alcohol as a forming medium. Results were compared with those from experiments with water-forming methods.

The experiment involved three primary processes and four supporting methods. All used the same mechanically fiberized furnish made in the disk refiner from crumbs at 50% moisture content. The primary processes were (a) water-laid, hot rewet (as described in previous section), (b) air-laid, cold rewet (as described in previous section), and (c) alcohol-laid, cold rewet.

In the alcohol-laid process, the fiber furnish was dispersed in ethyl alcohol rather than water or air. The alcohol extracted water from the fiber, reducing its moisture content to near zero. Handsheets were formed in a sheet mold using alcohol as the fluid medium. After forming, the alcohol-saturated web was held for 48 h in a humidity-controlled room at 90% relative humidity where the alcohol evaporated and the fibers regained moisture to approximately 18% moisture content. The web was then rewetted with cold water, wet pressed, and press dried in the manner of the air- and cold-water-laid webs. In this way, we were able to compare air-laid and liquid-laid webs made with dry fiber. To verify that no fines were lost in the forming process, a sample

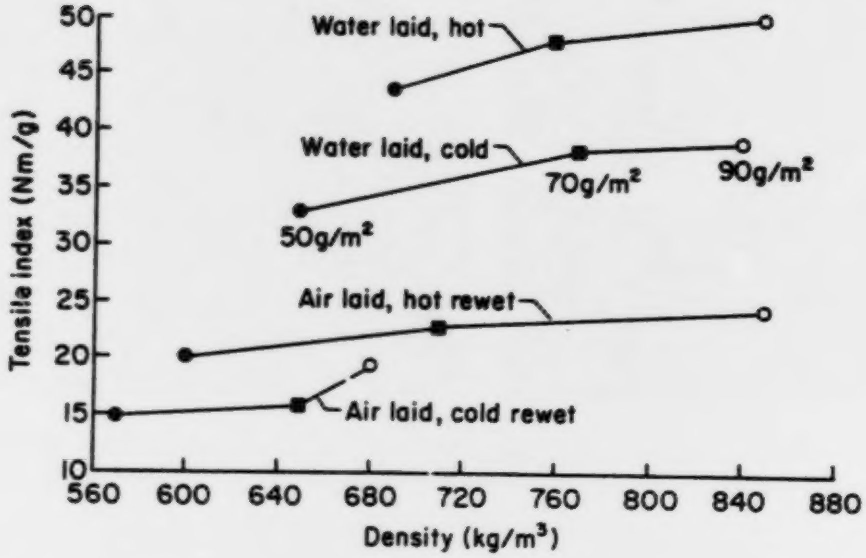

Figure 5. Density and tensile strength of water-laid and air-laid handsheets weighing 50, 70, and 90 g/m². Temperature of forming and rewetting water was 19° C (cold) or 55° C (hot).

TABLE 4. PROPERTIES OF AIR-LAID AND LIQUID-LAID HANDSHEETS*

Web type	Tensile index (nm/g)	Density (kg/m³)	Fiber length+ (mm)
A. Hot water laid	44.8	723	1.00
B. Air laid	17.5	683	1.07
C. Alcohol laid	21.7	640	1.07
D. Alcohol wash, air laid	17.8	637	1.06
E. Hot water soak, alcohol wash, air laid	23.6	660	1.04
F. Hot water soak, alcohol laid	27.9	700	1.01
G. Hot water soak, alcohol wash, hot water laid	49.3	726	1.00

*Press dried at 149°C, 3.0 MPa.
+Weighted fiber length determined by Kajaani FS-100.

of each handsheet type was dissolved in water after forming and then analyzed in the Kajaani FS-100. The results show no significant variation in weighted average fiber length (Table 4).

A comparison of tensile index values for handsheets made from webs A and B (Table 4) shows that the hot-water-laid web significantly outperformed the air-laid web. Comparing B to C, we note that performance was only slightly improved by alcohol laying of the dry fibers. The results indicate that the reduced performance of the air-laid webs was not simply a function of fiber placement or arrangement in the web but also involved the relative ability of the fiber to bond with other fibers in the network. Web types D through G verify that (1) bond potential of the

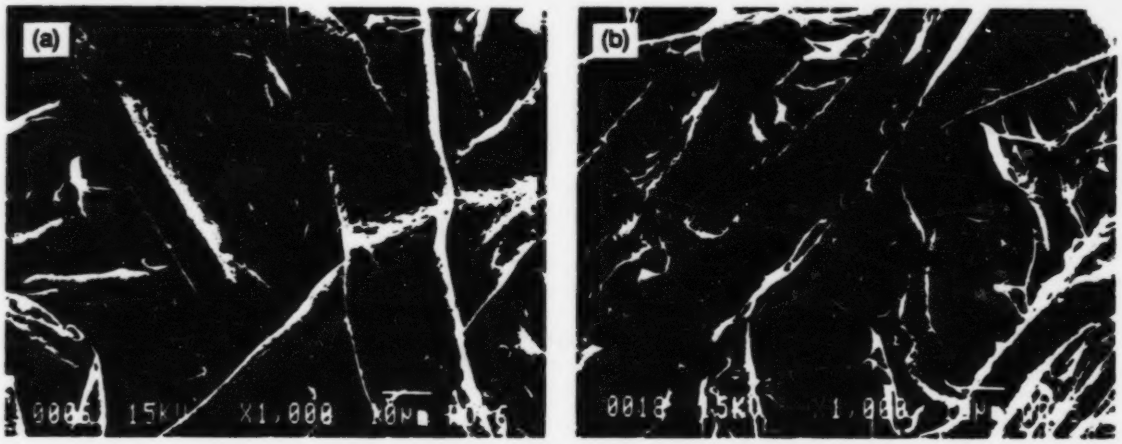

Figure 6. Scanning electron micrographs of air-laid (a) and water-laid (b) handsheets at 1,000x. Handsheets were formed from the same dry-fiberized furnish; differences in fiber fibrillation and fibrillar bridging of bond sites are apparent.

air-laid fiber was not diminished by the alcohol wash (compare D with B), (2) a hot water soak to remove latency (residual twist and curl in the fiber) prior to forming was helpful even in air-laid webs (compare E with D), (3) a hot water soak was helpful for dry fibers, alcohol laid (compare F with C), and (4) the alcohol wash did not reduce the strength or bonding potential of hot-water-laid webs (compare G with A).

The failure of the alcohol-laid web C to perform significantly better than the air-laid web B leads us to infer that the performance of webs formed from dry fibers will not be greatly improved by further refinements in forming methods. That is, the challenge appears to lie with the fiber itself: its fibrillation, forming flexibility, and ability to re-establish strong bonds within the web. We see evidence of this challenge in Figure 6. The air-laid web (a) shows almost no evidence of fiber fibrillation; the wet-laid web (b), which was made from the same fiber, exhibits extensive fibrillation and bridging of bond sites—characteristics known to be associated with effective bonding and development of sheet strength.

CONCLUDING REMARKS

Old newspaper (ONP) can be mechanically fiberized at moisture contents ranging from ovendry to >50% moisture content with a high yield of individual fibers. The potential for fiber damage (shortening of mean fiber length) is greatest at low moisture contents. At moisture contents from ovendry to approximately 20%, individual fibers can be disentangled from fiber flocks relatively easily and paper particles (nits) can likewise be separated from fibers. Disentanglement of fiber groups becomes significantly more difficult as moisture content increases above 20%. A variety of methods (machines) are potentially useful for fiberizing, but the fiber product is highly sensitive to operating parameters. We have not systematically optimized any of the methods we evaluated.

In our best effort to date, we fiberized ONP at 52% moisture content—retaining 97% of the fiber length measured in the control pulp obtained by the wet-disintegration in hot water. When wet-formed into 70 g/m^2 handsheets and press dried, this dry-fiberized pulp delivered 93% of the tear strength, 69% of the tensile strength, and 46% of the tensile energy absorption capability of the control pulp. Thus far, our best air-laid/press-dried method has produced handsheets with 91% of the density and 53% of the tensile strength of water-laid/press-dried handsheets made from the same dry-processed fiber.

How then can the strength and toughness (tensile energy absorption) of air-laid handsheets made from mechanically fiberized pulp be improved? At least four possibilities are apparent:

1. Optimize the mechanical fiberizing process to retain fiber length *and* enhance rebonding potential.

2. Chemically modify the fiberized ONP to activate lost bonding potential.

3. "Enrich" the ONP furnish with long fiber, either virgin or recycled, from higher grade products.

4. Add "adhesive" to the air-laid fiber and/or to the rewetting water.

For the present, our experience with dry disintegration of ONP and air laying of newsprint-weight webs does not dispute the wisdom of 100+ years of development in papermaking. Wet-forming methods are hard to beat. Dry or semidry processing of newsprint will not come easily—and it may never be successful. However, if the demand for urban recycling of ONP is sufficiently strong, there is enough promise in our results to warrant further effort and exploration.

ACKNOWLEDGMENTS

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International Conference on Pollution Prevention:
Clean Technologies and Clean Products

Session 37: Hazardous Waste Minimization in DoD Operations
June 12, 1990

DOD OIL AND HAZARDOUS SUBSTANCES POLLUTION PREVENTION PROGRAM

by
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Office Deputy Assistant Secretary of Defense (Environment)

ABSTRACT

The Department of Defense (DoD) is continuing to expand its Pollution Prevention/Hazardous Waste Minimization Program. In 1988, DoD presented an extensive report to Congress on DoD hazardous waste minimization efforts. In 1989, DoD issued a DoD Directive on "Hazardous Material Pollution Prevention." The goal of this directive is pollution prevention, rather than "end of the pipe" solutions, throughout DoD. The preferred method of pollution prevention is to avoid or reduce use of hazardous material through selection and management over their life cycle. DoD's pollution prevention program also includes prevention of, preparedness for, and response to oil and hazardous substance spills under the National Contingency Plan. This session consisted of a panel of representatives from the Office of the Deputy Assistant Secretary of Defense for the Environment (ODASD(E)), each of the Military Services, and the Defense Logistics Agency. Panel members discussed pollution prevention/hazardous waste minimization programs and planned initiatives within their Components.

PRESENTATION

Good afternoon. This is Session 37 on DoD Hazardous Waste Minimization. I'm Brian Higgins, an Environmental Engineer in the Office of the Secretary of Defense (OSD). I work for Bill Parker, who gave one of the keynote speeches at the Plenary Session yesterday morning.

If you haven't had a chance, I recommend that you visit the DoD exhibits downstairs. We have exhibits for OSD, the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), the Navy, and Rocky Mountain Arsenal.

Our speakers, who we will introduce in more detail a little later, are:

o Bob Bartell from USATHAMA,
o Paul Yaroschak from the Navy's Office of the Chief of Naval Operations (CNO),
o Major Brian McCarty from the Air Force Systems Command (AFSC), Brooks Air Force Base, and
o Joe Hoenscheid from the Defense Logistics Agency (DLA).

Bill Parker spoke about many topics yesterday which I don't need to repeat here. Something that may not be covered elsewhere in this Conference is something I have had first hand knowledge of for the last 1.5 years as DoD's representative on the National Response Team (NRT).

As you may know, the NRT is responsible for national policies and procedures in preparing for and responding to spills of oil and hazardous substances as part of the Clean Water Act and the Superfund Acts. EPA is responsible for consulting with the NRT, which is composed of 14 federal agencies, in developing the National Oil and Hazardous Substances Pollution Contingency Plan, better known as the National Contingency Plan (NCP).

For more than 20 years, DoD has had an Oil and Hazardous Substances Pollution Prevention and Contingency Program. Our Directive requires that we be represented on the NRT and on the Regional Response Teams (RRTs). Our bases are supposed to have Spill Prevention Control and Countermeasures (SPCC) Plans and Spill Contingency Plans so that every aspect of our operations is covered by some pre-planning, equipment, and construction, in some cases, to prevent spills in the first place, and to clean them up if they do occur.

We're responsible for reporting spills to the National Response Center (NRC).

EPA or the Coast Guard provide the On-Scene Coordinator (OSC) for oil spills on or from our bases. We are responsible for cleaning up all of our own spills, for acting as OSC for our hazardous substance releases, and for providing the Remedial Project Manager (RPM) for long-term responses on our bases.

A large part of our effort is to assist EPA or the Coast Guard in responding to emergencies caused by others. I have a personal example, one which you are all very familiar with -

the Exxon Valdez incident. Since 1980, the Naval Sea Systems Command Supervisor of Salvage (NAVSEA SUPSALV) has had an agreement with the U.S. Coast Guard for mutual support in the event of oil or hazardous substance spills in the marine environment. The Coast Guard and Exxon called SUPSALV for assistance within 12 hours after the Exxon Valdez went aground. The Air Force Military Airlift Command was flying Navy equipment from California to Alaska within 1.5 days, and it was also transporting equipment from Scandinavia and the Soviet Union for use in Prince William Sound.

During an interview about 40 days after the spill began, Admiral Yost, the Coast Guard Commandant, described the Navy equipment on scene and made the comment "Thank God for the Navy Supervisor of Salvage."

The Mega Borg incident in the Gulf of Mexico has, of course, received national attention this week. The Coast Guard has called in some Navy salvage experts to help in supervising the ship owner's contractors on-scene and asked for some Navy oil skimmers to be ready if needed.

Since this is an International Conference, I've gotten calls from other countries for information and/or assistance from DoD. Two weeks ago, EPA received a cable from the Philippine government requesting help with 45 leaking barrels of anhydrous hydrazine, a very toxic and explosive substance, at a Philippine Navy base. Jim Makris, EPA's Director of Chemical Emergency Preparedness & Prevention and Chairman of the NRT, requested technical assistance from DoD. We had some Air Force experts from Tyndall AFB, Florida, Kelly AFB, Texas, and Clark AFB in the Philippines, as well as Navy explosives ordnance demolition (EOD) personnel from Subic Bay Naval Station assist EPA and the Philippine government.

SPEAKERS

Our first speaker, going in order of Service seniority as usual, is BoB Bartell, from the U.S. Army Toxic and Hazardous Material Agency at Aberdeen Proving Grounds. He's the Chief of the Research and Technology Development Branch. He has 10 people working for him, and he's responsible for about a $12 million/year program to develop technologies for our Installation Restoration Program (IRP) and Hazardous Waste Management. He's been with USATHAMA since 1980, and he's grown up with the IRP, which has grown tremendously since then. We talk frequently with EPA. Russ Wyer, who was Chief of the Hazardous Site Control Division, mentioned that one of the first groups that they talked with in 1979-80 when they were getting into the Superfund business was USATHAMA, because of

THAMA's experience going back to the mid-1970s in site studies and cleanups at several of our bases.

Bob Bartell: "The Army's Hazardous Waste Minimization Program" (separate paper)

Just a sidelight. The Army's Chemical Demilitarization Program Manager at Aberdeen Proving Grounds used to be part of USATHAMA. The Army is DoD's Executive Agent for demilitarizing our chemical weapons. They currently have a $3 billion program to dispose of our unitary chemical weapons by incineration. With some of the arms control agreements, that may increase in the next few years. With the Chem Demil Program is a $150 million emergency preparedness program in which the Army is working closely with FEMA and EPA to prepare for any eventuality in the storage and disposal of these weapons.

Our next speaker is Paul Yaroschak, who is the Head of the Shore Facilities Environmental Protection Branch in the Office of the Chief of Naval Operations. As such, he is responsible for developing policy for a $100 million/year shoreside environmental program for our Navy. His responsibilities include getting funds for that program and seeing that it functions properly.

Paul Yaroschak: "Hazardous Waste Management: Making it Happen" (separate paper)

Next is Major Brian McCarty, a Bioenvironmental Engineer with the Air Force Systems Command in their Center for Hazardous Materials Management at Brooks Air Force Base, Texas. His co-author, Jeffrey Short, who is also here, was scheduled to speak, but kindly deferred to Brian to do the standup. Jeff is with the Air Staff at Bolling Air Force Base, here in DC.

Major Brian McCarty: "U.S. Air Force Hazardous Materials Management Initiatives" (separate paper)

Our next speaker is Joe Hoenscheid, a Senior Environmental Specialist for the Defense Logistics Agency. He is the Program Manager for the Agency's overall hazardous materials management program. He has worked in our part of the Office of the Secretary of Defense, for the Defense Reutilization and Marketing Service, for the Defense Logistics Services Center, and for the DoD Inspector General on a special assignment to review DoD Hazardous Waste Management. He is the Deputy to Walker Beddoes, who some of you may know is the Chief of DLA's Regulated Property Disposal Office.

Joe Hoenscheid: "Defense Logistics Agency Comprehensive Hazardous Materials Management Program" (separate paper)

QUESTIONS AND ANSWERS

Q. Jeff Short, U.S. Air Force: What is DASD(E) doing with the General Services Administration? GSA provides hazardous materials sometimes, also.

A. I'm not aware of anything that we are doing directly with GSA. Our Directive on hazardous materials pollution prevention came out nearly a year ago, on July 27, 1989. It calls for an annual briefing to the Assistant Secretary of Defense (Production and Logistics) on progress in implementing the directive. We're looking to a meeting with the Components late next month to see exactly where we stand in a lot of these areas and to prepare the briefing for ASD(P&L).

A. Joe Hoenscheid: As of late last year, the hazardous property disposal people in GSA, along with some other groups, were planning to convocate a meeting of federal officials to talk about just where the whole program would go within the federal government. We were expecting that to get off the ground by now, but don't think it has.

A. Jim Edward, EPA Office of Pollution Prevention: There is going to be a conference of federal agencies on recycling in October. It will be a joint thing with EPA and GSA. Right now the scope is fairly limited to recycling and not waste reduction.

Q. David Wigglesworth, Alaska Department of Environmental Conservation: One thing I'm curious about, at the base commanders level, as the bases try to implement some of these measures, how the mechanisms are going to transfer this work, through directives or other means? My other question is how can state programs assist in helping with that whole process. We've got a number of ideas. The federal agencies in Alaska certainly are a large contributor to our waste stream.

A. That's an excellent question, and each of the Services may address it a little bit differently. After our directive, one major step is our initiative with EPA to look at model bases and come up with a hands-on guide for our base commanders on how to implement pollution prevention in many areas, not just hazardous waste, but transportation, energy, and a number of other areas. We just started meeting with EPA in developing that concept. It would be similar to a guide which USATHAMA came out with last year for base commanders in the whole realm of environmental compliance. It's easy reading, take-home, bed stand type of thing, but it really covers a wealth of information for the base commander who may have career experience in infantry, but also in leading and commanding and in taking responsibility. He can pick that up and see what he needs to do and determine which of his staff he needs to bring in to do all of these things. You should work with the base commander because he is responsible for what happens on his facility and for working with the State and local governments and the local communities.

Q. In terms of human health and the effects of hazardous materials, the thing we tend to rely on in the field is the Material Safety Data Sheets (MSDSs). We have a system in place to put all these MSDSs into CD-ROM, which is really nice and handy for getting the information at the base level. But my main concern is how complete and accurate are the MSDS data?

A. There is no question that some of the data sheets are sketchy and questionable. DLA and our Force Management and Personnel people are developing a better Hazardous Management Information System (HMIS) and Hazard Communication System to satisfy OSHA requirements. I would hope that the MSDS data is upgraded as time goes by.

Q. How are you practicing pollution prevention in your Installation Restoration Program?

A. As Bill Parker mentioned in his keynote speech yesterday, Section 121 of CERCLA states that the remedial action preference is for treatment to permanently and significantly reduce the volume, toxicity or mobility of hazardous substances. We would have to look at individual feasibility studies or records of decision to get specifics, but this preference should always be part of our selection of remedy process.

END

International Conference on Pollution Prevention:
Clean Technologies and Clean Products

Session 37: Hazardous Waste Minimization in DoD Operations
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DLA COMPREHENSIVE HAZARDOUS MATERIALS MANAGEMENT PROGRAM

by
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Regulated Property Disposal Office
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ABSTRACT

Until 1986, the Defense Logistics Agency (DLA) had a number of individual programs dealing in varying degrees with the management of hazardous material and hazardous waste. Each program was very worthwhile and commendable in its own right. However, these were individual efforts, often lacking agency-wide visibility and central direction. To provide a coordinated approach to hazardous material and hazardous waste management within DLA, a task group consisting of representatives of the cognizant DLA Directorates developed the DLA Comprehensive Hazardous Materials Management Program (CHAMMP) - the basis for continued management efforts in this arena. The task group took a "life cycle" approach in developing the Program. The six phases in the life cycle of DLA managed hazardous property are:

- Determination of requirements
- Design
- Acquisition
- Supply systems (that is, how the hazardous material is transported, stored, issued, etc., by our Defense Depots)
- Consumer use (DLA) - This phase deals with how hazardous material is used within DLA itself
- Disposal

CHAMMP has been incorporated into the DLA Strategic Plan and provides for the continued "cradle to grave" management of DLA controlled hazardous property. It is a "living plan," reviewed and revised on a continuing basis to meet the changing environmental challenges. This briefing elaborates on each of the phases of the plan.

PRESENTATION

The Defense Logistics Agency's business is support - specifically, furnishing materiel support and services to the military. If the U.S. military forces fight with it, eat it, wear it, burn it (fuel, that is), push its buttons, or use it to carry out any of a thousand tasks related to combat readiness, chances are that DLA buys, stores and ships the item to the Military Services. We manage more than 2.8 million supply items in all, and each shares a common trait; whether pasta or spare part, each item is a consumable.

Our cradle-to-grave materiel support role starts at the predesign phase and continues throughout the life of the product until, eventually, we dispose of items no longer needed by the Services. During this process. DLA continually emphasizes total quality management, which stresses quality throughout the production cycle. Some 50,000 civilian personnel and 1,000 military, engaged in a wide variety of occupations and skills, carry out DLA's logistics responsibilities at facilities that span the globe.

To assure the support essential to readiness, DLA uses an array of technical, administrative, and managerial skills ranging from computer programming to mechanical engineering. Whatever the occupational specialty, our work force applies its expertise in supporting the Military Services by:

- Buying and providing quality goods,
- Administering contracts, and
- Performing technical and logistics services.

The DoD components use some 4.8 million national stock numbered items. The growing inventory of commodities that we manage - spare parts, clothing, fuel, food, medical and construction supplies - represent 69 percent of all items used by the armed forces. While only a small portion of these items are considered hazardous materials, they require close and continued attention to comply with environmental mandates, assure the safety of those personnel that handle them and preclude environmental degradation.

It's difficult to pick up a newspaper, magazine, turn on the TV, even listen to the radio today without being exposed to some reference to the environment. If the commentary doesn't address new legislation or costly compliance, it all too often concerns instances of damage to the environment. In some cases the damage is alleged to be the fault of a federal facility or that of an activity of the Department of Defense (DoD). The environmental authorities, as well as the special interest groups, are quick to point where we may have failed.

The recent Defense Environmental Restoration Program annual report to Congress cited two significant quotes that emphasize the importance the Administration places on environmental compliance. From the 1988 Presidential campaign, the statement by President Bush that "Federal facilities should lead the way in environmental compliance;" and from Secretary of Defense Cheney on 10 October 1989 "...this Administration wants the United States to be the world leader in addressing environmental problems and I want the Department of Defense to be the Federal leader in Agency environmental compliance and protection."

The continuous oversight by Congress, the General Accounting Office, the Inspector General, the Department of Justice, the Environmental Protection Agency and the environmental authorities of the states, coupled with the heightened environmental awareness of a sensitive public, challenges us to examine the way we do business and seek constant improvements in the management of hazardous commodities. The Comprehensive Hazardous Materials Management Program, or CHAMMP, is part of the DLA effort to address those challenges.

Up until 1986, DLA had a number of programs and initiatives involved with the management of hazardous material and hazardous waste. However, these programs and initiatives were instituted and managed exclusively by the affected functional element. For instance, the Directorate of Supply Operations had several ongoing programs at the Defense Supply Centers and Depots which dealt with packaging and transportation of hazardous material stocks; safety and health professionals with the Office of Installation Services and Environmental Protection were implementing programs at the DLA field activities in conjunction with the OSHA Hazard Communication Standard; the Defense Reutilization and Marketing Service in Battle Creek, Michigan, was proceeding with various hazardous waste disposal initiatives; and so forth. Each of these initiatives was very worthwhile and commendable in its own right; however, these individual efforts, driven by diverse requirements, often lacked agency-wide visibility and were frequently being pursued without central coordination or direction.

To provide a coordinated approach to hazardous material and hazardous waste management within DLA, the Director designated the Director of Technical and Logistics Services as his Executive Agent. Under this authority, a task group of representatives of the cognizant DLA Directorates was convened to develop a DLA Comprehensive Hazardous Materials Management Program - the basis for continued management efforts in this arena.

The task group took a "cradle-to-grave" approach in developing the program. This chart shows the six phases in the life cycle of DLA-managed hazardous property that were identified:

- o Determination of requirements
- o Design
- o Acquisition
- o Supply systems (that is, how the hazardous material is transported, stored, issued, etc., by our Depots)
- o Consumer Use (DLA) - This phase deals with how hazardous material is used within DLA itself,
- o Disposal.

Within each of the six life cycle phases, we identified one or more subphases or actions. A total of 26 subphases are incorporated into the program.

The task group then made a complete review of all the Principal Staff Element (PSE) hazardous property management responsibilities and actions. We noted a great deal of duplication or contradiction of effort. An example of this is in the area of training. We discovered that our supply operations people were developing and providing hazardous materials handling training for their Defense Depot stock-handlers completely independent of the similar training being developed and conducted by the Defense Reutilization and Marketing Service for its hazardous property disposal personnel.

The task group rolled all these hazardous property management responsibilities into the program with an eye to eliminating duplications or contradictions. Continuing with the training example I just mentioned, we established an initiative whereby development of all hazardous property-related training courses is reviewed annually to preclude unnecessary duplication.

The "meat of the program," however, is in its Hazardous Material Management Initiatives, or HMMIs. Offices of Primary and Collateral Interest (OPI/OCI) are assigned to each one. Some of the HMMIs have joint action within DLA; that is, two or more DLA Directorates are involved.

The DLA OPIs have developed implementation plans for each HMMI. These implementation plans identify milestone actions and target dates for completion of those actions. At the present time we have 90 HMMIs identified with a total of 254 separate milestone actions.

The program is reviewed by the PSE representatives and is briefed to the Director or Deputy Director on a periodic basis.

LIFE CYCLE OF DLA-MANAGED HAZARDOUS MATERIALS

I	II	III	IV	V	VI
DETERMINATION OF REQUIREMENTS	DESIGN	ACQUISITION	SUPPLY SYSTEMS	CONSUMER USE (DLA)	DISPOSAL
● Planning	● Engineering	● Solicitation	● Supply Management	● Waste Minimization	● Program Policy
	● Research & Development	● Source Selection	● Depot Procedures		● Receipt
	● Specifications	● Contracting	● Packaging & Transportation		● Reutilization Transfer and Donation
	● Packaging Specifications	● Quality Assurance	● Space Management		● Sales
	● Product Identification	● Contract Administration	● Quality Control		● Ultimate Disposal Programs
			● Training		● Special
			● Safety & Health		● Facilities

As this is a "living-plan," new initiatives are introduced as others are completed or revised. Recent review of the program increased the number of initiatives from 59 to the current total of 90. As the program embraces the life cycle management of HM for DLA it has been incorporated intact into the DLA Strategic Plan. Due to the number of HMMIs, rather than discuss each individual initiative, we will discuss their overall objectives in each phase of the program.

PHASE I - DETERMINATION OF REQUIREMENTS. This phase is not viewed as a DLA responsibility, but is seen in the context of when the DoD component perceives the need for a product or system. However, we saw an opportunity to reduce hazardous waste at the end of the life cycle of hazardous property by minimizing the inclusion of hazardous materials at the front end of the life cycle in the requirements planning process. Thus, the Directorate of Contracting (DLA-P) has completed an initiative to make a change to the DoD Supplement to the Federal Acquisition Regulations (DFARs) to require planners to minimize the inclusion of hazardous materials in their requirements determinations. A formal case was first presented to the DAR Council in January 1988. However, action was deferred by the DAR Council for lack of formal DoD environmental guidance to sanction change to the Acquisition Regulations. Upon publication of DoD Directive Number 4210.15 on Pollution Prevention, the case was resubmitted in September 1989 and has resulted in January 1990 coverage in the Acquisition Regulations. This will mandate DoD-wide consideration of hazardous material minimization objectives for all new major acquisition requirements at the front end of the process.

PHASE II - DESIGN. In the design phase we have identified ten initiatives that fall within the five subgroups shown on the chart.

Our Engineering initiatives consider minimization of hazardous materials through revision of specifications, materials substitution, specification evaluation criteria and manufacturing processes.

In Research and Development, we have an initiative to coordinate with and influence the Military Services to minimize the use of hazardous material in their systems as they are designed and modified.

In Specifications, we are incorporating hazardous property requirements in training courses for preparation of acquisition specifications.

We have initiatives to improve Packaging Specifications to prolong or eliminate shelf-life, and to revise preservation, packaging, packing and marking requirements to ensure adequate protection during transportation and storage.

Product Identification actions consider the application of item reduction, interchangeability and substitutability programs to reduce the number of hazardous items in the DoD inventory and the number of items that become hazardous on expiration of shelf-life.

PHASE III - ACQUISITION. In the acquisition phase we identified five initiatives.

We are reviewing Solicitations for procurement specifications, material standards, and purchase description criteria to ensure that shelf-life items have a minimum of 85 percent shelf-life at time of delivery.

As an adjunct to the DAR Council case I mentioned a moment ago, we have a joint action with OSD which seeks to introduce Source Selection criteria into the acquisition regulatory procedures which would favor suppliers who use hazardous property minimization processes.

In Contracting, the Defense General Supply Center in Richmond, Virginia, is utilizing and evaluating the results of a contract clause covering hazardous material inspection and acceptance which allows contractors to be charged DLA costs to correct or dispose of improperly contractor-packaged shipments.

We have established a Quality Assurance initiative to upgrade contract requirements as needed to include origin inspection for shipments to Depots; review of sampling procedures; judicious use of certificates of conformance; and use of quality assurance letters of instruction.

Contract Administration efforts are establishing specific controls to ensure contract compliance for labeling, packaging and quality assurance.

PHASE IV - SUPPLY SYSTEMS. There are currently 22 HMMIs in the supply systems phase with eight new ones under development.

In Supply Management, actions include review of procedures in the materials returns program to monitor system abuse from the return of unusable material and identify offenders back to the Military Services. An initiative addresses procedures to minimize hazardous waste generations through central management of hazardous materials. The DLA suggestion program encourages input from all levels of hazardous property involvement by making recommendations at regularly scheduled personnel management surveys.

Depot Procedures call for review of procedures to expedite processing of items in not-ready-for-issue condition.

Under Packing and Transportation, procedures have been established for correcting deficient or nonconforming packing. This initiative provides for immediate repackaging by the Depot, expedited follow-up actions by the Defense General Supply Center (DGSC), Quality Assurance Representative (QAR), Contracting Officer, and notification to the contractor. Also addressed is an initiative to assure that hazardous materials are received from the manufacturer packaged in compliance with contracting requirements.

We are developing a list of preferred packagings and containers for hazardous property managed or stored by DLA. We have developed a plan to implement the United Nations Performance Oriented Packaging (effective date - January 1991).

In Space Management. we have reviewed and revised storage systems for maximum space utilization (through adjustable pallet racks, etc.), and identified a method for DSCs to review, forecast, and adjust stockage levels to meet storage segregation and facility requirements.

In the area of Quality Control, we have established procedures for Depot surveillance inspectors to monitor specific hazardous material storage requirements (e.g., segregation protection).

Under Training, we have standardized hazardous material packaging training to appropriate Depot receiving personnel and QARs. We have implemented a mandatory hazardous materials handling certification training program for Depot personnel. We have reviewed the ongoing training programs and the development of training to preclude unnecessary duplication of DLA training efforts.

In the area of Safety and Health, we are pursuing resolution of problems related to the refinement of the Hazardous Materials Information System (HMIS). We have developed initiatives to ensure implementation of the OSHA Hazard Communication Standard as well as the implementation of OSHA hazardous waste operations and emergency response requirements. We have also evaluated acquisition programs, major facilities, and process changes to determine if system safety applications were necessary.

PHASE V - CONSUMER USE. Consumer use in DLA is addressed in our Waste Minimization programs. Programs have been established to provide Primary Level Field Activities (PLFAs) with direct assistance in the development and implementation of waste minimization programs to comply with the Resource Conservation and Recovery Act (RCRA). This plan calls for PLFAs to establish waste minimization committees, and provides DoD Headquarters DLA technical assistance teams to visit field activities to develop site specific waste minimization plans. We are considering an additional HMMI regarding decentralization of funding for hazardous waste disposal to the field activity level.

PHASE VI - DISPOSAL. This brings us to the final phase - Disposal. To ensure that environmental safeguards are incorporated into all phases of the disposal program, the phase has been recently revised to include a total of 40 HMMIs that address overall policy, receipt of hazardous property at our disposal yards, screening and sales of hazardous property, contracting for disposal, conforming storage facilities, and special categories of hazardous materials, such as medical items, precious metals, and ammunition boxes.

Under Program Policy the CHAMMP has been incorporated into the DLA Strategic Plan. One of our key initiatives is to incorporate the environmental leadership goals outlined by the Deputy Assistant Secretary of Defense (Environment) last fall as they pertain to hazardous property disposal. These goals include: cultural change, compliance, people, organizational structure, budgeting, training, communications and public affairs, and regulatory climate. Other initiatives concern the revision of the Federal Property Management Regulation, the Defense Utilization and Disposal Manual, and revision of guidance on handling third party disposal sites.

Receipt initiatives address training, storage requirements, hazardous material identification and turn-in requirements.

Under Reutilization, Transfer and Donation, we have initiatives to include liaison with state and federal agencies to better identify hazardous materials offered for their further use, review disposal program policy with GSA and tightening controls on hazardous property issued to screening customers.

Under Sales, emphasis is on efforts to ensure that procedures for conducting national sales emphasize environmental safeguards, including procedures to determine whether prospective purchasers are environmentally responsive. Our surveillance program, which has been used exclusively to monitor our ultimate disposal contractors, has been expanded to include hazardous materials and waste use and disposition by our sales purchasers. We also have an action to promote the DoD recycling program.

In the area of our Ultimate Disposal contracting, we are reviewing our contracts to ensure that they are written to result in environmentally safe and legally compliant hazardous waste disposal.

Also, we are exploring alternatives for reducing contract disposal costs through implementation of alternate disposal procedures such as use of DoD facilities (IWTPs, incinerators), on-site treatment by contractors (used oil, solvents, PCBs), mobile incineration, and changes to contract specifications (RCRA, non-RCRA). We have provided for long-term contracts (multiyear through use of options). We are revising our retrograde procedures in conjunction with OASD and CINCPAC in order to facilitate the retrograde of PCBs in Japan. In this regard, we have an initiative to gain EPA approval to retrograde U.S. owned foreign manufactured PCB items for ultimate disposal action. We have begun to perform liaison with industry and the Military Services to discuss common management efforts and initiatives, and to learn more of their capabilities as well as provide information on DLA HMMIs.

Under Special Programs, 2 HMMIs address environmental consideration in the precious metals recovery program. Federal Supply Class 6505 medical items are receiving special attention for DLA disposal mission assumption. This does not include infectious or pathological waste.

Finally, our Facilities planning actions provide for evaluation of alternatives to construction of conforming storage facilities to include portable facilities, shared facilities and continued 90-day hazardous waste removal.

In Summary, the DLA plan has been presented to the Deputy Assistant Secretary of Defense for Environment and accepted as a landmark effort for life cycle hazardous materials management and waste minimization. It has been presented to the Military Services at the Departmental level and to other federal agencies. The recent revisions to the initial program increased the management initiatives from 59 to 90 with additional actions under consideration; and the program, in total, has been incorporated into the DLA Strategic Plan.

The development of the program has been a challenging process and has indeed been a "learning exercise" for all who have been involved. It has provided opportunities for the key DLA players to gain a better appreciation of the varied roles that the PSEs play in the management of DLA hazardous property, the specific problems activities deal with, as well as the common problems we share.

END

Testimony of

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at the

HEARING ON POLLUTION PREVENTION

before the

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Committee on Small Business
Subcommittee on Environment and Labor
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ECONOMIC INCENTIVES FOR RECYCLING: AN EXAMINATION OF U.S. ENVIRONMENTAL POLICY FOR FINANCING RECYCLING FACILITIES

by: Scott L. Hoffman
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INTRODUCTION

Flexible, cost-effective market mechanisms have been used successfully in the past to address small or dispersed pollution sources, activities or products which are not very amenable to traditional rules and enforcement. Market-based approaches to environmental concerns must be used more widely in the future to manage environmental problems. successful use of economic incentives to address recycling of used oils, which are currently dumped in trash cans, sewers and back yards by tens of millions of consumers, can provide a model for broader application to the nation's environmental law framework in which economics reinforce environmentally-desirable behavior to encourage and increase recycling of tires, batteries and other components of the waste stream, without case-by-case government intervention.

THE PROBLEM

The nation's environmental policy has sometimes ignored the problem of financing environmental facilities. To ensure that environmental facilities are developed and continue to operate, laws and regulations must provide a reasonably predictable revenue stream to the operator to satisfy financial institutions that loans received to construct the facility will be repaid. These financing considerations are particularly important where a major goal is to expand capacity to serve an expanding market.

AN EXAMPLE

One bill now before the U.S. House of Representatives is The Consumer Products Recovery Act of 1989 (H.R. 2648). H.R. 2648 would increase operator's ability to finance and operate used oil recycling facilities. Under the Bill, operators would generate a double revenue stream, from sale of credits as well as recycled product. This revenue stream provides a level of predictability that will help ensure that the recycling project will support debt service.

CONCLUSION

Incentive approaches are neither new nor radical. Environmental statutes have long relied on negative incentives to push people towards compliance. Moreover, there is a large body of implementation experiences, at EPA, in Europe and elsewhere, on which Congress and EPA can draw to assure that flexibility is accompanied by continued environmental progress. While it raises some implementation issues, H.R. 2648 goes in the right direction. It represents one good chance to move from a static regulatory system to a dynamic one that continually generates needed reductions in pollution and risk from within.

INTRODUCTION

Mr. Chairman and Members, I am honored to testify today on the use of economic incentives, or more generally, market approaches, to address the problem of used lubricating oil and encouraging environmentally-sound recycling of this oil. My remarks concern the Consumer Products Recovery Act of 1989 (H.R. 2648), the principal market-based vehicle before the Subcommittee today.

Flexible, cost-effective market mechanisms have been used successfully in the past to address small or dispersed pollution sources, activities or products which are not very amenable to traditional rules and enforcement. Market-based approaches to environmental concerns must be used more widely in the future to manage environmental problems. Successful use of economic incentives to address recycling of used oils, which are currently dumped in trash cans, sewers and back yards by tens of millions of consumers, can provide a model for broader application to the nation's environmental law framework in which economics reinforce environmentally-desirable behavior to encourage and increase recycling of tires, batteries and other components of the waste stream, without case-by-case government intervention.

I should make clear that I am testifying today as an independent expert on use of economic incentives to address difficult environmental issues, not on behalf of any particular client, agency or constituent group.

My qualifications to speak in that capacity include five years' experience in development and financing of environmental facilities throughout the United States. These facilities include municipal solid waste incineration facilities, recycling facilities, waste coal power production facilities, waste tire power production facilities, landfill methane gas power production facilities, and medical waste disposal facilities. I coordinate the Environmental Facilities Finance and Development Practice of the Project Finance and Development Group at Nixon, Hargrave, Devans & Doyle, a 250-attorney law firm with offices in Washington, D.C. and throughout the country.

This testimony was prepared with the assistance of my colleague, Michael H. Levin. Mr. Levin's qualifications include nine years' experience, beginning in the Carter Administration, as founding director of the Environmental Protection Agency's ("EPA") Regulatory Reform and Regulatory Innovations Staffs, where he was responsible for implementation of the air "bubble," emissions trading, and other incentive approaches that cut regulatory costs and expanded compliance options while maintaining or accelerating environmental progress. The idea of using a ticket or "credit" system to encourage used oil recycling, and answers to many early implementation questions, originated on those staffs during his tenure. His qualifications also include considerable experience over the last 15 months with environmental permitting and the risks of financing compost, waste-to-energy, infectious waste and other environmental facilities. He was actively involved in the recent Project 88 Report sponsored by Senators Wirth and Heinz. He currently chairs the Clean Air Working Group's Project 88 Task Force, which is attempting to develop American industry's umbrella positions on use of market approaches under the Clean Air Act.

I want to focus on two key topics: why incentives are necessary and how I think the Consumer Products Recovery Bill would work, with some specific suggestions for improving and strengthening that proposal.

WHY ECONOMIC INCENTIVES?: THE LIMITS OF TRADITIONAL REGULATION

Market or incentive approaches are necessary not because they save money (which they've been shown to do in large amounts), nor because they reduce resistance and compliance delays (all of which they can), but for environmental reasons. Without them, this country can no longer accomplish the environmental policies demanded by the People. Like intractable smog, stratospheric ozone depletion, the general municipal solid waste crisis, and greenhouse warming, the used oil problem collides with the inherent limits of traditional regulation and cannot be solved by centralized commands alone.

What are these limits?

- Poor agency information about further feasible ways to control the thousands of diverse products and activities that contribute most remaining pollution.

- Limited government resources to throw at these problems in an age of budget austerity.

- Soaring control costs, totalling perhaps as much as $150 billion per year now with no end to perceived crises or cleanup expenses in sight. Cost may or may not be a consideration; but compliance is. No company or country can do everything at once; the smaller the sources or risks we seek to regulate, the higher the costs per unit of protection, and the smaller the environmental returns. As with Oreos or VCRs, the higher the cost, the less people are willing to buy.

- Slow government responses to new knowledge or rapidly-changing circumstances through rules tailored to specific industrial processes or substances. Such rules require massive data, take years to complete, and often freeze past control techniques, instead of stimulating new ones.

- Few motives for regulated sources to do or disclose more than the minimum required, since such disclosure makes them targets for further regulation.

- Third-generation problems caused either by bakeries, body shops and other small dispersed sources or activities, or by large sources whose further control threatens raging regional conflicts.

Transcending these limits requires changes in lifestyles, behaviors and local economies--results difficult to achieve with traditional rules or enforcement. Moreover, as the Prohibition Era taught, placing intrusive, mandatory restrictions on ordinary citizens tends to erode the compact on which social progress depends. Only a shift towards regulation plus incentives can deal with such problems by better matching individual interests with environmental goals. In short, we must make it profitable for people and companies to reduce pollution, as well as comply.

That shift has been underway for more than a decade now at EPA, which in response to diminishing returns of conventional regulation has implemented or seriously explored use of incentives in over a dozen air, water, pesticide and waste programs, which are summarized in the attachments to this statement. It is worth noting that the EPA's air emissions trading policies are estimated to have saved the economy over $5 billion in conventional compliance costs, from a relatively small number of transactions.

The EPA has steadily extended such approaches to new air pollution sources, to fleetwide and interfleet trades for tailpipe compliance by cars and trucks, to control of runoff from nonpoint sources, and to a variety of other circumstances. The EPA's stratospheric ozone program relies entirely on market approaches. Most significant for today's hearing, the EPA's lead phasedown program cut lead in gasoline by 90% within four years, while saving smaller refiners about $200 million annually over the cost of refinery-by-refinery compliance, through a credit system nearly identical to that in the Consumer Products Recovery Act proposal.

After exhaustive analyses, both the General Accounting Office and the Conservation Foundation concluded that: such incentive approaches have saved up to 90% of the cost of conventional regulatory compliance, without compromising environmental quality; EPA has solved such critical implementation issues as how to set fair "baselines" for measuring credit, how to avoid "paper trades" and phony reductions, or how to streamline procedures so these measures could be easily used; and market approaches should be expanded, since their "notable benefits" (increased flexibility, incentives for innovation, and easier enforcement, as well as more rapid, inexpensive compliance) were only a sample of things to come.

If it follows his June 12 specifications and is enacted, the President's Clean Air bill will accelerate this shift by legislatively endorsing broad market approaches for control of acid rain and urban smog--the first example of such explicit endorsement since Earth Day.

THE TORRES BILL

The Consumer Products Recovery Act of 1989, H.R. 2648, builds directly on this experience. When originally conceived as a regulatory measure, the problem for resolution was how to increase recycling by millions of dispersed do-it-yourselfers and service station operators when the cost associated with the oil was already negative--people had to pay to have it hauled away. At the same time, the associated concern was that hazardous waste regulation under the Resource Conservation and Recovery Act would simply increase irresponsible dumping.

The original answer was to link production and recycling, as well as stabilize recycling markets, by requiring producers of virgin lubricating oil to have a ticket showing, for example, that one barrel must have been properly recycled for each four new barrels made. Tickets could only be produced by recycling under appropriate management standards; they could be freely traded or sold by recyclers to the highest bidder; their value would be high enough to decrease the disposal price for service stations and do-it-yourselfers, as recyclers competed to collect used oil; and the overall cost of used oil recovery would be minimized, since refiners would recycle, up to the point where it was cheaper to buy tickets from others. In short, market forces would take care of the problem, except for government intervention to make sure "recycling" was environmentally sound and that credits were not sold to two buyers at the same time.

H.R. 2648 represents a substantial and appropriately cautious improvement over this initial concept, in part because it no longer runs the dual risk of constraints on production of virgin oil or the government printing tickets to make up any shortfall. Instead it sets mandatory, progressive recycling requirements for substantial producers and importers of virgin lube basestock, based on their prior annual production, and allows these requirements to be met by any combination of self-recycling (e.g., direct rerefining), direct purchase of recycled basestock, or credits generated by other rerefiners or reprocessors producing specification, off-specification or hazardous-waste fuel (where any contamination cannot be reduced to de minimus levels).

The Bill continues to recognize that recycling is demand-pulled, not supply-driven. Mandated recycling is counterproductive if markets for the recycled commodity are so thin, marginal or erratic that recyclables return to sewers or landfills.

Like EPA's stratospheric ozone rules, it maximizes administrability and enforcement by applying recycling requirements to a relatively small universe of less than 200 basestock producers and rerefiners, relying on the pull of positive prices to draw used oil into the management system from those farther down the chain. Like the widely-hailed lead phasedown model, it creates a streamlined tracking system which both assures proper recycling and lets recycling credits be easily traded, based on normal business records. It also reduces regulatory barriers by providing automatic "permits by rule" to recycling facilities that meet management standards, and for a self-executing plan by which EPA may extend similar incentive approaches to encourage feasible recycling of used newsprint, tires, batteries and other commodities.

FINANCING COMPLIANCE: CREATING A LEGAL FRAMEWORK THAT ADDRESSES FINANCING OF FACILITIES

A significant aspect of the Bill is the attention given to financing recycling facilities. The nation's environmental policy has sometimes ignored this important feature. To ensure that environmental facilities are developed and continue to operate, laws and regulations must provide a reasonably predictable revenue stream to the operator to satisfy financial institutions that loans received to construct the facility will be repaid. These financing considerations are particularly important where a major goal is to expand capacity to serve an expanding market, as described in the attached article on medical waste disposal.

For example, when Congress responded to the energy crisis of the 1970's, it understood that new power production facilities could not be developed without financing. The Congressional response was the Public Utility Regulatory Policy Act of 1978 ("PURPA"). PURPA requires utilities to purchase the electricity produced by certain "qualifying facilities" at the utility's avoided cost. Because of this Congressional requirement, developers of power facilities can apply for construction loans based on a predictable, Congressionally-mandated, revenue stream. Thus, money received from the utility that is required to buy the electricity serves as collateral for the loan. The success of new power facility development since PURPA's adoption is well-documented.

Similarly, H.R. 2648 would increase operators' ability to finance and operate used oil recycling facilities. Under the Bill, operators would generate a double revenue stream, from sale of credits as well as recycled product. This revenue stream, although not as predictable as the PURPA framework, nonetheless provides a level of predictability that will help ensure that the recycling project will support debt service.

IMPLEMENTATION ISSUES

No bill or rule is perfect. Indeed, seeking perfection rather than reasonable progress is usually counterproductive in the environmental area, making the perfect the enemy of the good. H.R. 2648 constitutes a big step in the right direction. But I want to point out some implementation principles, drawn from experience with representing financial institutions, and with incentives under other environmental statutes, that could allow potential pitfalls to be easily fixed.

- Be predictable. Because cash flow is critical to success and incentive approaches ask people to change their behavior based on money or investment decisions, baselines for credit and the procedures for generating it must be as clear and unambiguous as possible. The bill needs a definition section which clearly defines such terms as "producer or importer" (including basestock), "lubricating oils" (including grease and hydraulic or transmission fluids), and "recycling" (making clear that oil recycling into controlled burning for energy recovery creates valid credits). It also needs to address the "lag-time" issue--what past year's production will be multiplied by the percent recycling requirement to determine producers' present obligations and the size of the current market, since the two cannot be simultaneous. And what does "begin to implement" in Section 3016(c) mean?

- Use functional definitions and criteria. Viewed broadly, the goal is not recycling per se, but reducing the impact of used oil and other discards on the environment. Any approach which meets this test should be eligible for credits, subject to management standards sufficient to address the core environmental problem (not hypothetical cases that are unlikely to materialize). These considerations are particularly important to avoid precluding new, unforeseen recycling technologies, especially for commodities other than used oil. For used tires, e.g., any reading that precludes controlled burning in waste-to-energy plants from meeting recycling requirements or generating credits would destroy the market rather than strengthen it. Similar functional criteria should be included to guide EPA in determining what additional commodities should be subject to recycling schemes, what contaminating substances must be tested for by recyclers (e.g., the smallest number consistent with reasonable protection), and when a full RCRA permit may be required (e.g., if, but only if, the Administrator determines such a permit is necessary based on site-specific factors, with compliance with management standards sufficient until a final Part B permit issues).

- Balance speed and discretion. Agency discretion is necessary and laudable, but can also result in litigation and delay. Since EPA can establish a 40% recycling requirement simply by doing nothing, there seems no reason not to establish a base year for annual production through mandatory reporting and apply a presumptive formula to years thereafter, with the burden shifted to producers to show that a different annual production volume should apply.

- Avoid perverse incentives. For example, the presumption in § 3015(c)(2)(B) that a "small quantity" of used oil is not contaminated could require small businesses or two-car families to divide their used oil into 5-gallon containers and deliver it separately to collectors--a result that interferes with recycling and makes little economic sense.

- Strengthen enforcement and credit trading. As with lead phasedown, sales and purchases of recycled oil or credits should be promptly reported to a computerized EPA system that automatically flags discrepancies. Data reported should include the sale price, so participants can make rational economic compliance decisions in a functioning market. Also, while the bill promises "stiff penalties" for violations, it does not expressly deliver on that promise. One way to do so is to impose noncompliance fees based on any recycling shortfall and the current price of oil sales or credits, in addition to normal RCRA enforcement. Those fees could then be used to purchase credits from recyclers, creating both a secondary market to smooth transactions and a safety valve if recycling capacity does not keep pace with demand.

- Address the role of the states. States are only required to seek authorization if used oil should be regulated as a hazardous waste. Their role in other contexts, and how H.R. 2648 would mesh with current state or local recycling programs, should be, but is not, addressed.

CONCLUSIONS

Incentive approaches are neither new nor radical. Environmental statutes have long relied on negative incentives to push people towards compliance; the Torres bill would merely add positive incentives to pull them there as well. Moreover, there is a large body of implementation experience, at EPA, in Europe and elsewhere, on which Congress and EPA can draw to assure that flexibility is accompanied by continued environmental progress. While it raises some implementation issues, H.R. 2648 goes in the right direction. It represents one good chance to move from a static regulatory system to a dynamic one that continually generates needed reductions in pollution and risk from within.

SOCIETAL ECO-SUSTAINABILITY: THE OPPORTUNITIES AND RESPONSIBILITIES FOR COLLEGES AND UNIVERSITIES

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ABSTRACT

If human societies are to become increasingly sensitive to the imperatives for "Eco-Sustainability," faculty and students within colleges and universities should become active leaders in helping to bring about those changes. The moves in society to shift the emphasis from a basically reparative to a more anticipatory and preventative philosophy, within government, industry and society at-large, will require substantially new modes of thinking and teaching. It will require new ways of interacting with our local and global eco-systems and with each other. If this is to be accomplished, fundamental changes will have to be made in many facets of society, including the trend of dramatic decreases in support for education, at all levels. Additionally, the trend in research funding to support only short-term projects that promise to yield economic benefits in the market place in two to five years, must be reversed in favor of longer term support for integrated research.

Since the scientific information presently available is inadequate for making the societal changes essential to ensure "Eco-Sustainability," increased emphasis must be given to the development of research and educational activities that will fill those voids. These activities should be interdisciplinary in nature and be designed to provide cybernetic feedback to society from the eco-systems upon which we are all dependent.

If this is to occur, governments, industries and society as a whole, must increasingly provide long-term support for research and educational activities designed to help society prevent or to avert eco-disasters rather than continuing to react to crises after they have occur. "Crisis" management must be replaced with "Eco-Sustainability" management. To accomplish this change in approach, education must increasingly be regarded as the essential investment in our future and not as has been too often the case, as an expense.

Course and curriculum changes will be essential within college and university-level engineering, political science, business, law, journalism, economics and many other areas. Eco-sustainability considerations must be woven into the entire

fabric of our social, political, economic and industrial decisions. Educators and researchers will be increasingly challenged to provide the essential and unbiased leadership essential for the transition to sustainable societies of tomorrow. In addition to helping to provide present and future generations of young people with the information and values essential for such challenges, continuing educational experiences must be provided for the currently practicing engineers, political leaders, and for industrial, financial, legal and media specialists. Also, the general public must be provided information, in usable and credible forms to help them make life-style and investment choices that will help make the transition.

In regard to research, the issues of "ozone-layer thinning" and "the greenhouse effect," underscore the urgency of the need for substantial increases in basic and society-integrated eco-sustainability research. Industrial processes and products must increasingly be assessed in comprehensive, life-cycle-impact studies to anticipate and to minimize the risks to sustainability. Increasingly, new products must be evaluated, not from the "cradle-to-the grave phases," but more broadly, from the "preconception-to-the reincarnation phases." Product designers, however, must be provided ecologically sound guidelines for the assessment of future and present products and processes. Research is urgently needed to provide these guidelines and evaluative methods.

INTRODUCTION

In 1854 Chief Seattle said, "The White Man's appetite will destroy the earth and leave behind only a desert." If he were with us today, he would assuredly say, "I told you so!!" His prophetic statements are becoming a nightmarish reality before our eyes, as thousands of hectares of tropical rain-forests are stripped of their valuable species for the short-term gain of the sale of produce for a few years before the soil becomes incapable of sustaining even subsistence agriculture.

While the desertification of the tropics is occurring, and the erosion of the productive capacities of many of the temperate zones is also accelerating, the destruction of aquatic resources, on a world-wide scale, is expanding at an increasingly rapid rate. Current human population growth and consequent demands upon the eco-system are increasingly ecologically, **UNSUSTAINABLE!** What is to be done about these trends?

Recently, while visiting a Dutch company near Amsterdam, the author observed the following two questions above the entrance to the working area of the company:

a. Are you here with the solution?

or

b. Are you part of the problem?

Perhaps, these apt and sobering questions should be the central questions for our conference here in Washington. Do we have the solution(s)? Or are we causing the problems by ignoring our educational needs and our reluctance to make the necessary changes in our priorities? I hope our panel and others throughout this conference will at least provide some methods for developing the answers.

ACTORS AND ACTIONS FOR SUSTAINABILITY

The first issue of 1990, of **INNOVATION**, is entitled, "Educating Europe? Universities Today and Tomorrow."[1] This issue contains seven articles devoted to the theme, "The Ethical Premises and Consequences of Education," and five articles devoted to the theme, "The Practical Consequences for the Processes of Reform of European Educational Systems." These articles form a valuable contribution to the debate of the roles of colleges and universities in the post "cold war" era.

Among the points made by the authors is one made by Martin Peterson of the University of Goteborg, of Sweden. He emphasizes that,

> "In september 1988, a manifestation of mutual connection and unity among European universities took place in Bologna. the 900th anniversary of the University of Bologna served as the convenient occasion. It was at Bologna that universalists such as Dante, Copernicus and Erasmus had received their education. Hence the significance of Bologna for the rapprochement of European educational and research traditions and emancipation from a sense of inferiority in relation to the USA and Japan. Four hundred thirty-four university Principals from eastern and western Europe, signed a Magna Carta of the European universities containing a declaration of the fundamental principles and tasks of the universities.
>
> The principles state that universities are everywhere autonomous institutions in the heart of societies, which otherwise may differ in construction due to geographical and historical conditions. The university investigates, evaluates and advances culture. In the confrontation with the surrounding world the university must be morally and intellectually independent of all political, ideological and economic power structures. In order to induce the meeting with an excuse for not expecting too much one participant coined a phrase: "Autonomy was never easy, but now it is very difficult." This was underlined in an almost facetious way by the ever present name of Fiat at the meeting, the car-industry being the sponsor of the anniversary celebrations. So how much autonomy is there and what is it worth?"[2]

Against this point, how can the universities be, as one of the other authors suggested, "The Cultural Intermediaries?"[3]

How can they be neutral cultural intermediaries when cuts in state funds are forcing them to turn more and more to funds from project oriented research, funded by industry or government with a very narrow time frame and content focus? Is that the direction to sustainable societies?

In another recent publication, "**TOWARDS AN ECOLOGICALLY SUSTAINABLE ECONOMY**,"[4] the organizers of the volume that resulted from a two-day conference held in Stockholm, Sweden, January 3 - 4, 1990, state, "The move in society to shift the emphasis from a basically reparative to a more anticipatory and preventative philosophy raises issues about strategies concerning decision making in problem areas characterized by different kinds of uncertainty. Such challenges cannot be met without a development of new indicator systems with regard to sustainability. It also calls for new forms of integration of ecological information into the economic national long-term planning." The volume includes materials devoted to topics such as:

a. Values
b. The interface between economy and ecology
c. Sustainability as a framework for national environmental goals
d. National policy instruments
e. The international dimension

The authors clearly indicate that colleges and universities must increasingly be active in meeting the challenges posed by the sustainability issue.

In a similar, but more narrowly focused vein, the issue no. 1 of ISWA TIMES,[5] published in early 1990, focuses upon the need for educators to meet the shortage of trained professionals in the U. S. and elsewhere throughout the world. An article by Dr. Diaz, of California Recovery Systems Inc, makes the following point, "The shortage of well-trained waste management professionals in the U. S. A. is serious, and the demand is being met by those only marginally prepared to tackle the complexities of the problems." -----"Problems associated with the management of municipal solid waste have reached difficult proportions throughout the United States. Despite the fact that they are widely recognized, little or no attention has been paid to the development of human resources to solve them."

Because of the recognized shortage of university attention to the development of adequate educational opportunities for students of all ages, Ralph Kummler and his associates at Wayne State University of Detroit, Michigan were recently provided a grant by the U. S. Dept of Health and Human Services to perform a study of hazardous waste education and training in the United States. Their study documents university course work and degrees as well as non-degree continuing education short courses.[6] During the study, 1469 four-year degree granting institutions were contacted. Of the 732 institutions responding, 113 were identified as offering course work of some kind in hazardous waste management. They found that the academic response for the provision of courses and the student response to participate in such courses would not fulfill the growing national and international needs.

They emphasize that the estimates of the need for professionals from 1990 to 1995 just to meet existing hazardous waste clean-up needs in the U. S. are 22,500. Further, they state that the U. S. Dept. of Health and Human Services estimates that 100,000 environmental professionals will be needed by 1992. They suggest that the lack of trained professionals impedes a viable U. S. policy in hazardous waste management as much as funding limitations.

Two points to be made about this study, are: a) of the 470 non-degree hazardous waste short courses offered, only 13 addressed issues pertaining to "Waste Minimization." b) of the three schools offering Masters Degrees in hazardous waste issues, only two had courses devoted to "waste minimization and recycling."

Additionally, with such a predominant focus upon hazardous waste management and such a scarcity of attention being devoted to the more comprehensive issues of waste minimization, pollution prevention and "Product Life Cycle" approaches to prevention or minimization of the generation of wastes in the first place, it seems unlikely that the progress that some companies have experienced with pollution prevention and waste minimization, will soon become the normative approach within the U. S. and elsewhere.

To this author's knowledge, no similar, comprehensive, assessments have been performed, in other parts of the world, of the needs for trained toxic and hazardous waste management professionals and of the provision of courses to meet these needs. However, based upon the needs within the U. S., certainly, the need worldwide must be in the millions. Millions are needed just to focus upon cleaning up the problems generated in the past and to pay attention to controlling those being produced today.

If we wish to address the challenges to move effectively from 'crises' management to 'prevention' management, throughout the world, the need and the urgency for major educational and research activities devoted to sustainability, becomes apparent. Responses to this need are beginning to emerge within colleges and universities in a few countries. However, much more must be done if society's needs for people educated in the integrative concepts of sustainability, are to be provided. If this is to occur with the speed that is needed, major funding changes will be essential. To this end, with the rapidly changing social-political-military-ecological situation of the world, it would appear desirable and timely to consider the reallocation of 50% of the financial, human and material's resources, currently devoted to military activities, to efforts designed to help ensure "**ECO-SUSTAINABILITY.**" Many military personnel have highly developed skills that could be directly applied to the necessary environmental work. Others, being retired early from the armed forces, could, with some intensive retraining, be effective in filling those thousands of positions for environmental clean-up and hazardous waste management.

Within the next few years, more fundamental reallocations of resources and refocussing of societal objectives must occur. As a modest proposal, since the very survival of societies is at stake, it would appear sensible that if as little as 50% of the world's resources, currently utilized for **"DEFENSE AGAINST HUMAN INVADERS,"** were redirected to **"DEFENSE AGAINST MOLECULAR** INVADERS," such as CFC's, PCB's, SO_x's, NO_x's, CO_2-excesses and others, that conferences like this one being held in 2020 would look back to the 1990's as the turning point in human history.

Now is the time, with the momentous changes that have occurred in many nations within the last year still fresh in our memories, to make bold new commitments. I propose that 1991 - 1995 should be the period during which all countries decide to initiate new, two-year training programs for all males and females, age 18 to 20, designed to help all to become proficient, "soldiers," in the **"ECO-SUSTAINABILITY DEFENSE FORCES OF PLANET EARTH."** These programs should be designed to help the youth, learn the basic skills of eco-sustainability. These programs should include the basic skills essential for monitoring and correcting the toxic substance problems that are threatening human survival. Other, illustrative skills to be learned, include habitat restoration, contaminated site clean-up, eco-agriculture, eco-aquaculture, eco-forestry, including reforestation of mined and otherwise denuded landscapes. All must also learn the basic lessons of the need for the development and efficient use of renewable energies. Lessons must also be directed to the reformulation of the organization of the infrastructure of cities such as Mexico City which, according to a recent report, currently has as many as 50% of its children suffering from various forms of lead related diseases. Such urban centers must be redesigned to be attractive and healthful centers for human habitation or the current civilization will become one more in the series of civilizations that became extinct.

As the youth, learn these and other basic eco-sustainability, skills and put them into practice while working within international teams throughout the world, such work will help to foster, within them, a deep respect for the laws of nature and a sense of purpose and unity with all other people. Thereby, many will increasingly learn that people of all colors and creeds can and must work together to help ensure sustainable societies.

After the youth have participated for their two-year period within the "Eco-Defense Forces," many may chose to enter the universities to further develop the skills necessary to becoming the new engineers, politicians, journalists, educators, etc., of tomorrow.

Faculty and staff of many of the colleges, universities and technical institutes, could be involved in the education of the youth during their two years of planetary service and in guiding and challenging them as they continue their subsequent studies.

Erasmus Universiteit in Rotterdam, The Netherlands is among those universities that is increasingly reflecting upon its responsibilities for developing educational and research opportunities in these areas. Illustrative of this is the fact that two new interdisciplinary courses will be taught, by the author, during the fall semester of 1990. These courses are entitled:

a. "Cleaner Production: Theory, Concepts and Practice"
b. "The Changing Context of Environmental Management: Redefining the Roles of Government"

During the autumn of 1990, the author will initiate an "Eco-Sustainability Education," working group within the UNEP "Network on Cleaner Production." Anyone wishing to become a participant is invited to contact him at Erasmus Universiteit.

CLOSING NOTES

The concept of Eco-sustainable societies is evolving. With this evolution, more and more attention must be addressed to the question, If we wish to help ensure sustainable societies, what changes must be made in the way we interact with our eco-system? While the answers to this question vary widely some tentative formulations of principles have been proffered for industrial leaders and governmental authorities to consider. One such formulation, **THE VALDEZ PRINCIPLES** is included as appendix # 1. The author urges all to reflect upon these principles and challenges everyone to work for the implementation of these principles throughout society.

Of course, as with any new ideas, there will be those who will say, "Yes that sounds good in principle, but it won't work in practice." Or "Let's think about that------later." My colleagues in the work psychology department of the Danish Technological Institute have assembled a list of 23, **PROVEN AND EFFECTIVE, 'NEW IDEA,' KILLERS.** They are included for your non-use in Appendix # 2.

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APPENDIX # 1

THE VALDEZ PRINCIPLES

The Valdez Principles, developed by the Coalition for Environmentally Responsible Economics (CERES), set standards for corporate environmental responsibility.

1. **Protection of the Biosphere:** We will minimize the release of any pollutant that may cause environmental damage to the air, water or earth. We will safequard habitats in rivers, lakes, wetlands, coastal zones and oceans and will avoid contributing to the greenhouse effect, depletion of the ozone layer, acid rain or smog.

2. **Sustainable use of Natural resources:** We will make sustainable use of renewable natural resources such as water soils and forests. We will conserve nonrenewable natural resources through efficient use and careful planning. We will protect wildlife, habitat, open spaces and wilderness, while preserving bio-diversity.

3. **Reduction and Disposal of Waste:** We will minimize waste, especially hazardous waste, and whenever possible recycle materials. We will dispose of all waste through safe and responsible methods.

4. **Wise Use of Energy:** We will use environmentally safe and sustainable energy sources to meet our needs. We will invest in improved energy efficiency and conservation in our operations. We will maximize the energy efficiency of products we use or sell.

5. **Risk Reduction:** We will minimize the environmental, health and safety risks to our employees and the communities in which we operate by employing safe technologies and operating procedures and by being constantly prepared for emergencies.

6. **Marketing of Safe Products and Services:** We will sell products that minimize environmental impacts and are safe as consumers commonly use them. We will inform consumers of the environmental impacts of our products or services.

7. **Damage Compensation:** We will take responsibility for any harm we cause to the environment by making every effort to restore the environment and to compensate those persons who are adversely affected.

8. **Disclosure:** We will disclose to our employees and to the public, incidents relating to our operations that cause environmental harm or pose health or safety hazards. We will disclose potential environmental health or safety hazards posed by our operations.

9. **Environmental Directors and Managers:** At least one seat on our Board of Directors will be designated for an environmental advocate. We will commit management resources to implement these Principles, including the funding of an office of vice president for environmental affairs or an equivalent executive position to monitor and report on our implementation efforts.

10. **Assessment and Annual Audit:** We will conduct and make public an annual self-evaluation of our progress in implementing these principles and in complying with all applicable laws and regulations. We will work towards the timely creation of independent environmental audit procedures to which we will adhere.

APPENDIX # 2.

A FEW REASONS WHY WE CANNOT TRY THIS NEW IDEA *

1. Don't forget that we must also earn money!!
2. You will never be able to sell this idea to the management.
3. Let's think more about that, later.
4. I know it's not possible.
5. We are too small/big for that.
6. We have already tried that. (We haven't.)
7. That will be too expensive.
8. Now, is not the right time for this discussion.
9. That will mean more work!!
10. We have always done it this way, so why should we change now?
11. You don't quite understand the problem!
12. Let's take it up again later.
13. In our branch it's different.
14. Let somebody else try it first.
15. It doesn't fit into our long term planning.
16. Talk to Hans, this is not my field.
17. We have already over-spent our budget for this year.
18. It won't work, and besides that, it's against our policy.
19. We have no time for that.
20. It sounds fine in theory, but how will it work in practice?
21. We don't have enough employees to implement that idea!
22. We are not ready for this idea yet.
23. It is too late to make changes now.

* Proven and Effective 'New Idea' Killers, adapted from materials developed by the Work Psychology Dept. of the Danish Technological Institute in Taastrup, Denmark.

THE LEGAL BASIS FOR WASTE AVOIDANCE AND WASTE UTILIZATION IN THE FEDERAL REPUBLIC OF GERMANY

Will A. Irwin*

The Federal Republic of Germany amended its Abfallgesetz (Waste Act) in 1986. Section 1a(1) of the Waste Act declares that "wastes shall be avoided in accordance, with regulations based on section 14(1), No.'s 3 and 4 and [section 14](2), Sentence 3, No.'s 2 through 5." (Emphasis added.) Section 1a(2) of the Act provides that wastes "are to be utilized" in accordance with section 3(2), Sentence 3 of the Act or to the extent prescribed in regulations promulgated under section 14(1), No.'s 2 and 3 and 14(2), Sentence 3, No.'s 2 through 4." (Emphasis added.) These provisions authorizing regulations for waste avoidance and utilization are set forth below.

Waste Avoidance

Section 14(1) of the Waste Act authorizes the Federal Government, for 'the avoidance or reduction of harmful substances in wastes or for their environmentally compatible management," to provide in regulations that

> "3. distributors of certain products are only allowed to put them on the market in connection with the offering of the possibility of returning them or the charging of a deposit on them," and
>
> "4. certain products may only be put on the market in a certain condition or for a certain purpose that ensures the proper management of their wastes or may not be put on the market if the management of their wastes cannot prevent the release of harmful substances or can only do so with unreasonably high costs."

Section 14(2) provides that the Federal Government is to establish "goals to be met within appropriate time limits for the avoidance, reduction, or utilization of wastes from particular products" and to publish these goals. To the extent necessary for the avoidance or reduction of waste quantities or their management in an environmentally compatible manner, especially to the extent this cannot be achieved by the goals established in accordance with Sentence 1 of section 14(2), Sentence 3 of that section authorizes the Federal Government to provide in regulations that particular products, especially packages and containers

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> "2. may only be brought onto the market in particular ways that contribute noticeably to waste management, especially in a form that can be used more than once or that facilitates utilization,
>
> "3. must be taken back by the manufacturer, distributor or third parties determined by them after use and that the return be ensured by suitable receiving and deposit systems,
>
> "4. must be transferred after use in a particular way, especially separated from other wastes, in order to enable or facilitate their utilization or other environmentally compatible management, and
>
> "5. may only be brought on the market for particular purposes"

Waste Utilization

Section 1a(2) of the Waste Act provides wastes are to be utilized in accordance with section 3(2), Sentence 3. That sentence provides that waste utilization has priority over other waste management if it is technically possible, its higher costs in comparison to other forms of waste management are not unreasonable, and a market for exists for the recovered materials or energy or can by created by hiring third parties. Section 14(1) No. 2, referred to in section 1a(2) concerning regulations authorized for waste utilization (but not in section 1a(1) concerning those for waste avoidance), states that regulations may provide that "wastes with particular contaminant contents whose proper utilization or other management requires special handling must be kept, collected, transported, or treated separately from other wastes," and that appropriate records of these efforts be kept. Section 1a(2) also authorizes regulations for waste utilization under section 14(1), No. 3 (but not 4), and section 14(2), No.'s 2-4 (but not 5), set forth above under those authorized for waste avoidance.

Section 1a(1) of the Waste Act also states that it leaves undisturbed the duty of operators of facilities that must obtain a permit in accordance with the Bundesimmissionsschutzgesetz to avoid wastes by employing low-waste processes or by utilizing residues. (section 4 of the

Bundesimmissionsschutzgesetz requires a permit for the construction and operation of a facility that, because of its characteristics or its operation, is likely to cause detrimental environmental effects or otherwise endanger or significantly disadvantage or burden the general public or the neighborhood. The Fourth Regulation Implementing the Bundesimmissionsschutzgesetz specifies the facilities that must obtain permits if they may be expected to operate for more than six months at the same location.)

Section 5(1) of the Bundesimmissionsschutzgesetz, last amended on October 4, 1985, requires such facilities to be constructed and operated so that 1) detrimental environmental effects cannot be caused, 2) precautions are taken against such effects, and 3) "residues are avoided unless they are regularly and harmlessly utilized or, if their avoidance or utilization is not technically possible or is unreasonable, can be disposed of as wastes without impairment of the common good" (Facilities that do not require a permit are to be operated so that the wastes they generate "can be properly disposed of." Section 22(1), No. 3.) Although "residues" is not defined in the Bundesimmissionsschutzgesetz, it includes all substances whose production by the facility was not intended.

In October 1988, draft administrative rules interpreting and implementing section 5(1), No. 3 were approved by the Laenderausschuss fuer Immissionsschutz. (Administrative rules are, in general, binding on government officials responsible for implementing legislation.) These draft administrative rules were recommended to the Laender as a basis for interpreting and applying the provisions of the Bundesimmissionsschutzgesetz discussed above to the facilities covered by that act and for the administrative procedures for doing so; some Laender have adopted the administrative rules.

Similar purposes exist for the document being developed under the Waste Act -- the draft "TA-Sonderabfall" (Technical Instructions - Special Waste), Part 1 -- that interprets the provisions of the Waste Act that waste utilization has priority over other waste management if it is "technically possible," its higher costs in comparison to other forms of waste management are not "unreasonable" and "a market exists" for the recovered materials or energy or can be created by hiring third parties. The TA-Sonderabfall also discusses permitting and enforcement procedures, e.g., the documents required for establishing the avoidance and utilization of residues.

The German Federal Government plans to issue administrative rules for the avoidance and utilization of residues and special wastes that are based on the provisions of both the Waste Act and the

Bundesimmissionsschutzgesetz. These administrative rules would apply to individual waste groups and would set forth the current state of the art of avoidance and utilization, criteria of economic reasonableness, and ecological considerations. The preparatory work for these administrative rules is being done by Working Group 7 of the "TA-Abfall (Technical Instructions - Waste)." Priority is being given to waste groups with high reduction potential, e.g., aluminum salt slags; organic solvents that contain halogens; dye and painting residues; galvanic sludges; spent foundry sands; inorganic acids; halogen-free organic solvent wastes; and oil emulsions. For each such waste group a sub-group of Working Group 7 is convened made up of representatives of business and industry, universities, and federal and state governments.

These administrative rules are being developed by the Federal Government in Germany because of its belief that economic markets alone do not provide adequate incentive for pollution prevention measures.

Germany provides subsidies to industry and research institutions to promote research and the demonstration of new technologies. There is also a government-industry commission to develop information of low-waste technologies for the use of industries that must comply with the laws and officials that must enforce them. A final factor that encourages source reduction and recycling in Germany is the limited capacity for treatment and disposal.

SEGREGATION FOR RECYCLE AND REUSE OF HAZARDOUS CHEMICAL MATERIAL AT LOS ALAMOS NATIONAL LABORATORY

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LA-UR-90-1116

1. INTRODUCTION

Los Alamos National Laboratory comprises 43 square miles in North Central New Mexico. The principal mission of the Laboratory is the design and development of weapons for the nation's nuclear arsenal; however, considerable research and development is directed toward developing the peaceful uses of nuclear energy, including research on controlled thermonuclear reactions, fission reactors, nuclear safeguards, laser fusion, and medium energy physics. Extensive basic research programs in physics, chemistry, metallurgy, mathematics and computers, earth sciences, and electronics support these efforts. Biomedical and environmental research includes programs in molecular biology, radiobiology, radio-ecology, and industrial hygiene. Expansion into nonnuclear areas is represented by applied technology development of solar and geothermal energy and superconducting power transmission lines.

2. POLICY

Pursuant to DOE Orders 5400.1, 5400.3 and 5820.2A, it is the policy of the Department of Energy to conduct its operations in a safe and environmentally sound manner. Protection of the environment and the public are responsibilities of paramount concern and importance to the Department. To this end, DOE is firmly committed to assuring incorporation of national environmental protection goals in the formulation and implementation of Departmental programs. Accordingly, all DOE Contractors shall institute a waste reduction policy to reduce the total amount of waste that is generated by DOE operating facilities, including radioactive waste, hazardous waste and mixed waste.

The Health, Safety and Environment Division, (HSE-DO) and Waste Management Group (HSE-7) have the primary responsibility for the management and minimization of waste.

3. ECONOMICS

In addition to regulatory requirements, Los Alamos National Laboratory recycles chemicals for economic reasons. As the cost of disposal (currently \$5-50/lb., depending on material) rises it becomes mandatory to reduce the amounts of materials in the disposal stream. Every pound of material that is recycled then saves up to \$50/lb. plus the cost of replacement materials that may be required in the future.

The prioritization of materials that are chosen for recyclability is based on the intrinsic value of the recycled materials. For this reason, recycling at the Laboratory is focused on precious metals, strategic metals, and bulk organics.

The value of precious and strategic metals is high as well as the cost of disposal these heavy metals and their oxidizer salts. The environmental impact of heavy metals is also important to the decision.

The Laboratory also uses a great deal of organic solvents. The use of these materials is being phased out by substitution, but in the mean time recycling is used to minimize the amounts that require disposal.

The economics of recycling becomes a matter of balancing the cost of disposal versus nthe cost of recycling, the environmental impact of disposal, and the limited financial and manpower resources available for recycling.

4. WASTE STREAM TYPES

In calendar year 1988, the Laboratory purchased over 19,000 different laboratory chemicals. Waste disposal records indicate as much as 40% of disposals are over-purchased laboratory chemicals. The diversity of chemicals requires us to limit recycling to various classes of compounds.

The Laboratory has few bulk, repeating waste streams. The organic solvents and machine coolants are the two waste streams that are routinely recycled. Scintillation fluids have been replaced by non hazardous substitutes.

5. SPECIFIC CASES AND RESULTS

a) Recirculating Laboratory Chemicals and Reagents

Chemicals that arrive at HSE-7 for disposal and are in reusable condition are pulled out by the disposal technicians and are set aside for redistribution. A monthly list of available chemicals will be circulated to user groups. Users will be encouraged to check the HSE-7 list before purchasing chemicals.

Certain chemicals of high value that are not recyclable by the above method will be offered for sale outside the Laboratory, first through the Reportable Excess Automated Property System (REAPS) and then by salvage through a limited end user system. Initial efforts will be focused on toxic, heavy metals, strategic metals, precious metals, industrial chemicals, and organic solvents. This salvage action is contingent on management and legal approval, based on liability issues.

b) Recovering Photographic Silver
the Laboratory has 70 photographic processing facilities. Each will be supplied with an electrolytic silver-recovery system for their facilities. This will eliminate disposing of silver-bearing wastes and provide an economic return to the Laboratory.

This recovery process has started and 50 facilities use recovery systems. A large recovery unit will be put into the new treatment facility for the recovery of the chemicals from the remaining 20 operations and large slugs that can not be handled by the existing units.

c) Replacing and Recovering Halogenated Solvent
The Laboratory uses F-listed halogenated solvents in almost all of its operations for degreasing, stripping, and cleaning. Efforts have been started to find replacements for each of these solvent operations on a system-by-system basis. Each operation is different and must be approached individually. In some cases, the use of a specific solvent is mandated by procedure, which would require an administrative change.

The Laboratory is also researching the economics and technical feasibility of distillation recovery of solvents to use in operations where no adequate substitution can be found.

d) Machine Coolants
All of the machine coolants in use at the Laboratory are being recycled through redistillation. The only new material used is the replacement for material lost in still bottoms.

e) Mercury

All elemental mercury is pulled out of the waste stream and recycled through distillation. It is them made available for reuse through the waste management group.

f) Lead
The amount of solid lead used for shielding material at the Laboratory is high. Currently, all lead is screened for segregation by radioactivity. Highly contaminated lead is sent to the LANL Radioactive Storage Area. Non contaminated lead is sent to the salvage yard for reuse through the Idaho Lead Bank. Slightly contaminated lead, 0-2 nanoCuries/gram, is reused as shielding at the Meson Facility.

g) Recycling Used Oil

Pan Am World services recycles 200 to 600 gallons of used motor oil per month for the Laboratory. A licensed recycler refines this motor oil into fuel oil.

h) Recycling Paper
The Laboratory has an active paper recycling program for office paper. The initial goal of 50% recycled paper has been exceeded an preliminary results in the first three months of 1990 indicate a 75% recycle of white office paper. White paper is recycled from all other grades of paper by the generator at their desks.

6. FUTURE PLANS

a) Chemical and Waste Tracking
Tracking of chemicals will be implemented to maintain better information on the location and status of these materials. Chemical and waste tracking within waste management will include cost data for transportation, destruction, and disposal of waste; a chemical tracking system enabling reuse or recycle of waste materials, as well as matching user requests with surplus chemicals marked for disposal; and access to the literature reporting industry-wide technological changes resulting in reduced waste.

This data base will contain:

a. Cost information for treatment and disposal. The data base will contain cost information for the sampling, packing, transporting, treating, and disposing of waste materials. Costs will be developed on a per unit-waste basis. This information will be used to inform the generator of the expense of waste management and the savings realized through waste reduction.

b. Waste materials inventory for Recycle/Reuse.
The data base will be used to record the location, quantity, and characteristics of waste materials throughout LANL. This information will be circulated among user groups who may have a need for the waste materials, thus recycling or reusing the waste whenever possible.

b) Bar-Coding
The Laboratory is developing procedures to initiate a bar-coding system for tracking the thousands of different chemicals that are purchased each year. This bar-coding system will be tied into the waste tracking system. Bar-coding will give WGI a handle on material flow that will provide information on purchasing trends and over-purchases, and the ultimate fate of laboratory chemicals.

This effort will be tied in with the data base that tracks purchased materials and reoccurring waste streams.

c) Recycling D38

The Laboratory is currently negotiating with Grants Metals Inc. to process the 1500 gallons a year of depleted uranium chips and turnings that the Laboratory generates. GMI has the patent on modifying the Ames process that recycles depleted uranium with virtually no environmental impact. The D38 is then put back onto the open market for reuse.

d) Treating Chromium Wastes
To reduce toxicity, the Laboratory is will begin treating chromium plating wastes by reducing Cr^{+6} to Cr^{+3}. Analysis is being done on the feasibility of further reducing to Cr^0. This would greatly reduce the liquid waste that must be disposed of and puts the chromium in a form that would not be readily available to the environment.

e) Copper Stripping Solutions Recovery
The Laboratory uses an ammonia-based solution for stripping copper in printed circuit-board manufacturing processes. This process produces a corrosive waste that must be neutralized.

Administrative procedural changes will require that copper be electrolytically removed from the Cu-saturated solution, greatly extending the useful life of the stripping solution.

WASTE MINIMIZATION STRATEGY
FLEXIBLE POLYURETHANE FOAM MANUFACTURE

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INTRODUCTION

Since the discovery of the diisocyanate polyaddition process by German chemist Otto Bayer in 1937, polyurethane chemistry has matured into a sophisticated industry with applications in numerous industries. By 1985, world manufacturing capacity for polyurethane foams had reached nearly five million metric tons located primarily in North America and Western Europe. In the 1960's to increase penetration into furniture component and bedding markets (displacement of latexes), polyurethane foam density was reduced (to increase softness) by the addition of auxiliary blowing agents to the formulations. The primary blowing process involves the reaction of an isocyanate with water to produce gaseous carbon dioxide which expands the foam network. The auxiliary foaming process involves no chemical reactions, but is merely a change of state of the auxiliary blowing agent (methylene chloride or chlorofluorocarbon). Volatilization of the auxiliary blowing agent from liquid to gas coincides with the primary evolution of CO_2 and urethane polymerization to provide a significant increase in the number and size of foam cells. The increase in cell size and number produces the low density desired for specific foam end uses. Historically, chlorofluorocarbons (primarily CFC-11) were utilized to decrease foam density due to the low boiling points, thermal conductivity, relative insolubility, and chemical stability. In the past two decades, CFC's have been linked to global warming and depletion of stratospheric ozone; consequently, many foam manufacturers have substituted methylene chloride as the auxiliary blowing agent. In addition to meeting market specifications for cushion softness and indentation, low density foams significantly impact profit margins by decreasing the amount of toluene diisocyanate (the most commonly used isocyanate) required in formulations and the amount of chemicals per cubic foot of product.

Global restrictions on the manufacture and emission of chlorofluorocarbons are rapidly propagating. As these regulations are enacted, the supply of current CFCs will tighten and the prices of CFCs are expected to dramatically increase. Additionally, air toxics legislation within various states may severely limit emissions of methylene chloride, a suspected carcinogen. Options available to foam manufacturers which limit air emissions while maintaining worker safety, product quality and profitability include:

- Eliminate the use of auxiliary blowing agents and only produce water (CO_2) blown foams. Several questions arise concerning the capability to make a wide range of low density foams. This limit directly affects corporate marketing potentials. Additionally, the negative cost impacts (higher raw material costs) to small and medium manufacturers would be significant.

- Substitute materials (such as HCFCs which supposedly have lower ozone-depletion and global warming potentials) as auxiliary blowing agents. Near and long-term production capabilities of these materials along with consequent foam properties are mostly unknown. In addition, manufacturing plants will probably be under pressure to minimize any organic emissions.
- Utilize new chemical systems to eliminate auxiliary blowing agents. These new systems require modifications to existing formulations and even some of the recent innovations that have been commercially introduced do not appear to be viable for low density foams.
- Invest in latest-generation enclosed machinery for batch foam processing. Although this option directly addresses air emissions, return on capital and production capabilities are very questionable. Control of product quality and consistency is generally more difficult in batch processes.
- Recover/recycle auxiliary blowing agents by modifying the current continuous process. Benefits include the maintenance of current chemical formulations, product qualities, worker safety, productivity, and profit margins. Recycling of auxiliary blowing agents would also offer a potential cost savings by reducing material costs.

The recovery of an auxiliary blowing agent is a complex issue coupled directly with another manufacturing requirement, the maintenance of safe plant working conditions in the presence of small quantities of isocyanates. Worker safety is presently maintained with adequate air flow to keep ambient isocyanate concentrations at acceptable limits (the maximum allowable indoor air concentration of TDI is 0.02 ppm). This air flow also lowers the auxiliary blowing agent concentrations to a range where recovery technologies are not economically feasible. Research objectives were to:

- quantify the dynamics of blowing agent loss in laboratory prepared foams using representative formulations,
- validate laboratory experimentation with analogous plant data, and
- examine innovative means to maintain safe worker conditions while simultaneously recovering the auxiliary blowing agent and minimizing air emissions.

Basic information on organic volatilization and concentration, recovery, and recycle of fugitive emissions is transferable to other chemical process industries.

EXPERIMENTAL OBJECTIVES

Prior experimentation has primarily dealt with the mechanistic chemistry applied to product development. Additionally, DuPont (1), other suppliers of halogenated hydrocarbons, and Unifoam (2), an equipment manufacturer, performed investigations on the emission of volatiles from polyurethane foams. Union Carbide (3), also a supplier of raw materials to the industry, conducted an elegant study on the sequence of events and kinetics of the most important reactions in the foaming process. Experimentation in the current study was focused on developing a basic quantitative understanding of the various processes involved in the manufacturing operation (specifically events occurring within the foaming tunnel, curing, and storage areas). Previously, these sequences were understood only qualitatively making the possibility of cost-effective recovery very low as evidenced by three decades of little change. The steady state plant process was successfully simulated using a laboratory batch preparation commonly utilized by the industry. The events which take place as the foam travels down the tunnel are represented in the laboratory-produced foam as a travel time. While the smaller scale introduces some limitations, it is apparent that similar events occurred in the plant situations and the essential processes were unchanged. To concentrate the research effort, only one type of auxiliary blowing agent, methylene chloride, was investigated over a range of foams. The specific objectives of the several experimental studies were as follows:

- Quantification of the rates of mass (volatiles) loss for a range of foams in an open system.
- Collection of volatiles in a closed system with determination of CH_2Cl_2 and CO_2 in various stages of the process (collection times related to times in and out of the foaming tunnel).
- Determination of the effect of vacuum application on the rate of mass loss in the curing and storage areas.
- Generation of interior foam temperature profiles throughout the process as a function of time.
- Collection of mass loss data at three foam manufacturing plants for comparison to and validation of laboratory data.

MASS LOSS EXPERIMENTS

A formulation (courtesy of Hickory Springs Manufacturing Company) for a typical polyurethane foam applicable for furniture components was utilized for laboratory experiments. This formulation yields a product with a density of 1.0-1.2 lb/cu ft with an indentation load deflection (foam resilience or firmness) of 21 lb. (the force required to compress a 4" thick slab to 3"). Additional formulations were utilized which varied the amount of methylene chloride to investigate the effects of changes in the ratio of primary to auxiliary blowing agents.

Laboratory foams were prepared using conventional techniques developed within the polyurethane industry. All formulation ingredients were weighed in tared beakers or syringes and added to a tared vessel; timing was started with the addition of toluene diisocyanate. After stirring (using a tared mechanical stirrer) the chemical mixture for approximately 12 seconds, the foaming liquid was rapidly transferred to a tared polyethylene (0.002" thickness) lined cardboard cakebox (12" x 12" x 6") sitting on an electronic balance. Pouring a completely mixed and foaming mixture onto a solid surface (cardboard) can be likened to the plant situation where a mixing head discharges onto a flat conveyor system. Typically, balance readings would stabilize at t=0.5 minutes and mass readings would be collected periodically for 24 hours. The stirrer and mixing vessel were also weighed at 24 hours (when all volatiles have been lost) to account for transfer losses by back-calculation. Experimentation covered a series of foams prepared with a range of auxiliary (methylene chloride) to primary (water) blowing agent concentrations (0:1, 1:1, 3:1, 4:1). Average mass loss data are presented in Figure 1. The laboratory data are characterized by an initial rapid loss of approximately 60-70% of the available volatiles in 10 minutes; the residual volatiles are then slowly lost over 24 hours. These two regimes of mass loss are logarithmically proportional to the elapsed time and represent a complex mechanism of volatilization. Simplistically, the first regime of

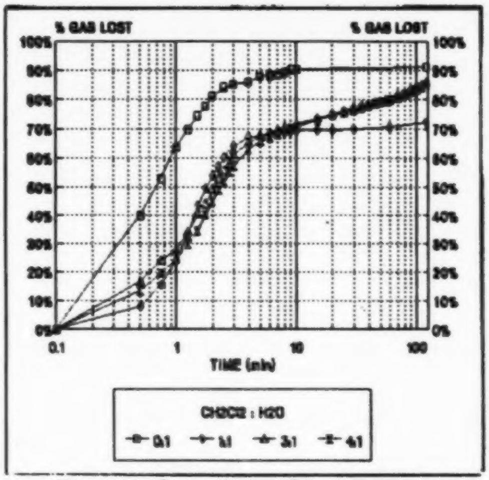

Figure 1 - Normalized Mass Loss Profiles

mass loss is hypothesized to relate to the kinetically fast reaction between the diisocyanate and water generating CO_2 and heat. The heat generated by the competing reactions increases the temperature of the foaming mass and the liberation of CH_2Cl_2 is initiated. The rapid loss of volatiles occurs from the surface of the rapidly expanding multiphase foam and from the block interior as the foam becomes an open cell structure (blow-off point). The second regime of mass loss appears to be a slow diffusion of volatiles through a open cell foam mass as crosslinking reactions continue. As the amount of methylene chloride is increased in the formulation (at constant water content), the mass loss rates increase. When the data are normalized on a percent of total volatiles lost, the time dependent mass loss rates and total mass loss over the first 10 minutes for 1:1, 3:1, and 4:1 formulations appear independent of the amount of auxiliary blowing agent present in the formulation. After 10 minutes, the normalized 3:1 and 4:1 data continue to coincide. Conversely, the mass loss rate for the 1:1 formulation noticeably slows after 10 minutes and looks similar in shape to the analogous water-blown (0:1) foam data. The reason for this behavior is unknown but may relate to a density effect. These observations support a rapid chemical rate of formation and loss of CO_2 followed by a temperature and diffusion dependent loss rate of CH_2Cl_2.

COLLECTION OF VOLATILES IN A CLOSED SYSTEM

To further understand the loss of volatiles from soft polyurethane foam and develop potential strategies for recovery/reuse of the auxiliary blowing agent, a successive batch collection of both carbon dioxide and methylene chloride was developed (4). Methylene chloride was gravimetrically determined by condensation in a tared alcohol/solid CO_2 cold trap. Carbon dioxide was adsorbed onto solid ascarite (primarily NaOH) forming sodium bicarbonate and water; CO_2 evolution equaled the increase in mass of the ascarite scrubber and an anhydrous $CaSO_4$ trap (for H_2O).

A polyethylene lined cakebox was fitted with two inlet and outlet tubes located about 50 mm from the bottom and positioned within a wire cage to support the air inlets, gas outlets, and an ingredients loading tube. This entire assembly was placed within a sealed (airtight) large plastic bag. Foam preparation was carried out in the usual manner; after stirring, the foaming liquid was poured through the filling tube which was quickly closed with a screw cap. A vacuum pump connected to the end of the first absorber train was started and gas collection was initiated for the first time period. At 10 minutes, the gas outlets were switched to a different absorber train for collection of volatiles for the second time frame. Each absorption train consisted of four cold traps in series (for collection of CH_2Cl_2) and one packed ascarite absorber with two drierite tubes (for collection of CO_2 as $NaHCO_2$ and H_2O). Particular care was exercised when the absorbers were disconnected for gravimetric determinations; tared drying tubes were connected to each sub-assembly to prevent entry of atmospheric water vapor. Average volatile collection data for 1:1, 3:1, and 4:1 formulations are graphically displayed in Figure 2. Independent of formulation, the ratio of methylene chloride collected to carbon dioxide collected increases as a function of time. When the data are normalized for percent of volatiles, the data are consistent with the normalized weight loss profiles. These observations support a rapid consumption of water (generation of CO_2) and a time delayed evolution of methylene chloride from polyurethane foams. For the less dense foam formulations (3:1 and 4:1), the greatest amounts of the available methylene chloride were recovered in the first ten minutes; however, the relative concentrations of methylene chloride were found to be greater in the subsequent twenty minutes.

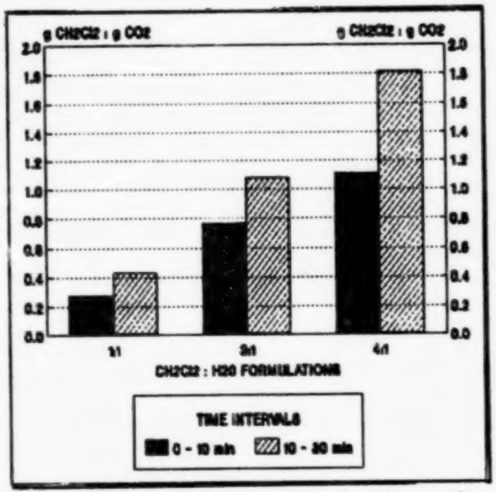

Figure 2 - Collection of Volatiles

In an attempt to get a better understanding of the loss profile for auxiliary blowing agents from polyurethane foams, normalized mass loss data for water blown foams with only CO_2 evolution were graphically subtracted from normalized mass loss data for the lower density foams that evolved both CO_2 and CH_2Cl_2 (3:1 and 4:1 formulations). The higher methylene chloride content (lower density) foams have the greatest potential for recovery/ reuse strategies. These extrapolated data are presented in Figure 3. Calculated $CH_2Cl_2:CO_2$ ratios increase as a function of time and thus exhibit the same patterns (but of greater magnitudes) observed for the closed system data described above. Since these data are calculated from averages of separate experiments, caution must be exercised in interpreting actual magnitudes. However, the observable trends are consistent with the reaction kinetics; i.e., a rapid loss of CO_2 and a time displaced loss of CH_2Cl_2. Calculated $CH_2Cl_2:CO_2$ ratios from the data yields values for the 0 - 10 minute interval of 0.77 (3:1) and 1.06 (4:1) which compare very favorably with the data displayed in Figure 2. The calculated 3:1 and 4:1 data coalesce when normalized on a percent of CH_2Cl_2 lost. Approximately 40% of the auxiliary blowing agent is left in the foam bun as it exits the tunnel. As the foam proceeds through the plant, the concentration of CH_2Cl_2 relative to CO_2 is enriched. These data emphasize the two phase nature of volatile loss and are critical information in understanding the time (plant location) dependent loss of the auxiliary blowing agent. Only by understanding the magnitude and rates of loss can appropriate recovery technologies be selected.

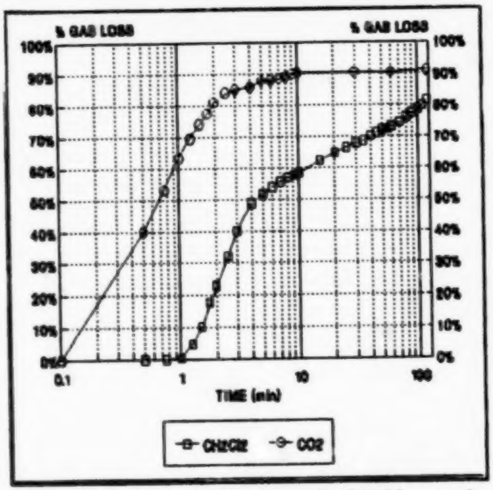

Figure 3 - Calculated CH_2Cl_2 and CO_2 Loss Profiles

EFFECT OF VACUUM ON MASS LOSS

Recognizing the two regimes of mass loss from polyurethane foams, exploratory tests were conducted to determine whether the application of vacuum to a freshly set foam would accelerate the rate of volatile loss. These experiments address the slow diffusion of volatiles (primarily the auxiliary blowing agent) within the manufacturing curing and storage areas.

Foam was prepared using the standard formulation at one-third of the normal batch weights (for a cakebox to fit in the available vacuum oven). Mass loss data were collected for foams in an open system (0 - 30 minutes). Analogous data were recorded for foams that were started in an open system (0 - 10 minutes) and then placed in a vacuum oven at ambient temperature (10 - 30 minutes). These collection times correspond to an average tunnel residence time of 10 minutes and an arbitrary post-tunnel interval of twenty minutes. The data demonstrate a significant effect ofvacuum application on the rate of diffusive losses from polyurethane foams. The application of vacuum increased the rate of volatile loss from set laboratory foams by at least three-fold. Additional experimentation needs to be conducted to quantify the degree of vacuum, optimum temperature, and actual time required to collect the residual volatiles from a foam block. The feasibility of vacuum utilization coupled with entrapment by condensation within the manufacturing environment is unknown.

INTERNAL FOAM TEMPERATURE MEASUREMENTS

Reactions of the isocyanate with water, polyol, and urethanes are all highly exothermic. Internal foam temperature measurements were recorded to establish the rate of heat generation in this system. Cross-linking reactions during the curing period are also be affected by the way generated heat is conserved in the system or lost to the environment. Measurements of the time dependent temperature profiles at various spatial locations within insulated and uninsulated foams were used to determine the effects of convective and conductive heat losses (4).

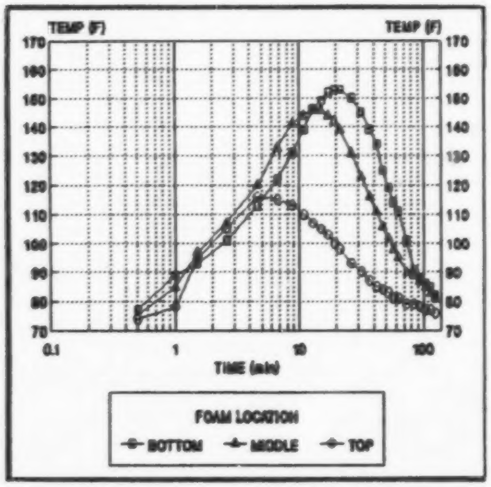

Figure 4 - Interior Foam Temperatures

Six calibrated copper-constant thermocouples were supported on a laboratory stand and located in an empty mold box to correspond to the desired points of measurement. The foam mold was placed inside a larger box. Polyurethane foam was tightly packed in the 2-3 inch spaces (sides and bottom) between the foam mold and the larger box for insulation. Three different levels and three different locations were measured in insulated and uninsulated molds (not all levels and all locations were determined for each insulation condition). The three levels were chosen at 0.5", 2.5", and 4.5" from the bottom of the foam mold (foam height at full rise was approximately 6"); the three locations were 0.5" from a side, a corner, and the center of the mold. To improve reliability, readings were carried out in duplicate runs. The six thermocouples were connected to a Leeds and Northrup Speedomax H Multipoint recorder which was equipped with an internal temperature compensator and a 200 °F - 2200 °F range card. Foam was produced in the standard fashion and poured into the mold box with thermocouples appropriately positioned. Special care was taken not to pour the foam onto the thermocouples or disturb the thermocouple positions. After completion of each test, the thermocouples were carefully cleaned to prevent set foam (insulating) from interfering in subsequent runs.

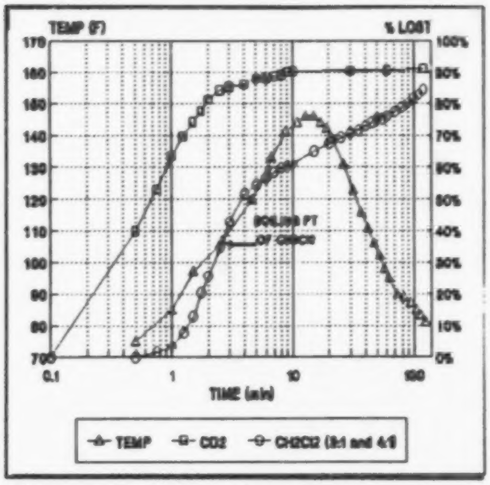

Figure 5 - Foam Temperatures and Mass Loss Profiles

Foam temperature data are graphically displayed in Figure 4. Interior laboratory foam temperature rises at approximately a linear rate (versus log time) and reaches a maximum of 150 °F after about 15 minutes and then gradually decreases. Therefore, temperature continues to rise well after the blow off point (opening of cell structures and maximum loss of volatiles). This observation implies that the cooling effect associated with gas evolution may not significantly contribute to the heat loss of the total system. To more fully understand this effect, a series of controlled thermodynamic experiments would have to be conducted. For uninsulated laboratory foams, the initial temperature rise appears independent of the vertical position within the mold. However, as the reactions progress, the temperature at the mold bottom reaches the highest maxima. This observation indicates that heat conduction through the foam bottom surface is not a major factor; therefore, mass transfer through the foam top surface is a major mechanism of heat loss from the system. Internal foam temperatures are plotted along with the mass loss profile (Figure 5). A loss of CH_2Cl_2 at temperatures lower than its boiling point (104 °F) is apparent. This phenomenon was unexpected and may relate to the fact that the CH_2Cl_2 loss data were calculated and not directly measured. If the loss of CH_2Cl_2 at temperatures below the boiling point is real, it conceivably might be explained by the thermal gradients present within the foam and that there is a net flow of gas (CO_2) out of the system which could sweep CH_2Cl_2 in the vapor phase out of the foam.

COLLECTION OF MANUFACTURING MASS LOSS DATA

Data were collected at three polyurethane manufacturing plants for comparison to and validation of laboratory experiments. Two of the plants (Hickory Springs and Leggett and Platt) utilize methylene chloride while the third plant (Olympic Products) utilizes trichlorofluoromethane (CFC-11) as the auxiliary blowing agent. Samples of production foam were cut and suspended; periodic mass loss data on each bun were obtained using a load cell. Initial bun weight (i.e., sum of input material weights) and initial bun volatiles were calculated. Mass loss data for the six manufactured foam samples are displayed in Figure 6. The plant data percent weight loss profiles and rate curves (not displayed) have the same general shape independent of the type or level of auxiliary blowing agent (analogous to observations on laboratory foams). The percent weight loss curves exhibit the same general shape; however, there is a spread to the data. There doesn't appear to be any pattern to the variations related to a specific plant, sample size, a specific auxiliary blowing agent, or a specific level of auxiliary blowing agent. These data are hypothesized to reflect random variations within the various manufacturing operations. The flattening of the mass loss profiles and mass loss rates of the plant foams is comparable to what is observed with laboratory foam at analogous measurement times. Based on the 30 °F difference in boiling points, CFC-11 would be expected to be volatilized earlier than CH_2Cl_2. Comparison of the mass loss profiles for foams of comparable formulation but with different auxiliary blowing agents yields conflicting data. CCl_3F comes off earlier in one comparison (C vs. D)while CH_2Cl_2 comes off earlier in the other (B vs. E). The time differential between the two boiling point temperatures in the manufacturing operation is small. Therefore, the loss behaviors of methylene chloride and CFC-11 from flexible polyurethane foams are expected to be similar.

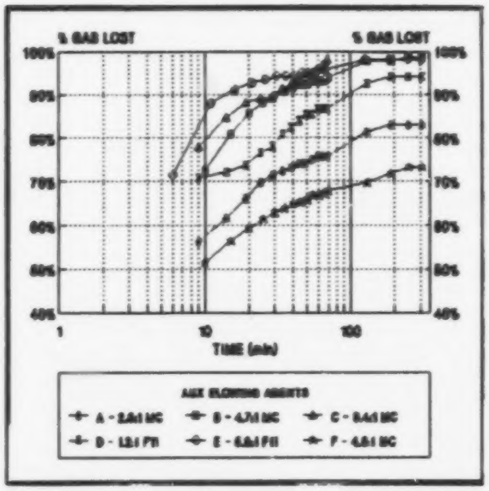

Figure 6 - Mass Loss Profiles
Plant Foams

In general, there is good corelation between the data on plant and laboratory foams with analogous formulations (Figure 7). The data suggests that the loss of volatiles from laboratory foams is more rapid than from plant foams. Lab foams have a higher percentage of exposed surface area per unit weight than large plant foams. Additionally, gases have a shorter distance (and probably a less tortuous path) to exit from lab foams and volatiles should escape more rapidly. Based on the mass loss profiles of the plant foams, there are significant amounts of volatiles (30 - 45%) remaining in the bun after the first ten minutes. Considering the reaction kinetics, this residual volatile material is theorized to be essentially only the auxiliary blowing agent which is lost by slow diffusion from the cooling foam mass. These experiments validate the laboratory data and confirm the bi-modal behavior of volatile loss from polyurethane foams. Consequently, any strategy for the recovery and recycle of auxiliary blowing agents must take into account the two distinct regions of loss rates.

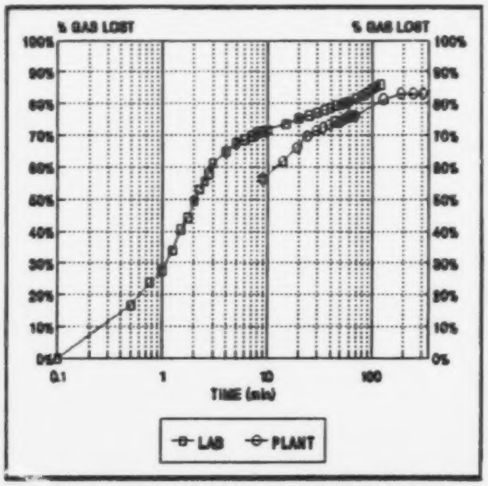

Figure 7 - Mass Loss Profiles
Lab vs. Plant Foams

CONCLUSIONS

We firmly believe that foamers will eventually be restricted in emitting any blowing agent. Retrofit of a foam line to isolate the tunnel and drastically reduce exhaust flows will eliminate worker exposure to isocyanates and significantly increase tunnel concentrations of the auxiliary blowing agent. This increase in ambient blowing agent concentration should allow for recovery by conventional means.

Collection and recovery of halogenated hydrocarbons such as methylene chloride and trichlorofluoromethane (CFC-11) by adsorption onto activated carbon (or carbon fibers) followed by steam-out and condensation has been documented in the literature (5,6,7,8) and commercial systems are available from many vendors. Two of the key parameters which drive the size and hence capital cost of a carbon-based recovery system are the concentration of the material to be collected and the flow velocity (9). The Center's approach to isolating the foam tunnel and decreasing air flows would positively impact the economics of any recovery system. The higher the concentration of auxiliary blowing agent and the lower the total flow, the smaller the carbon bed required (lower cost). The recovery of auxiliary blowing agents from polyurethane foam exhaust gas appears to be technically feasible. Design parameters and economic feasibility of various recovery options including emerging technologies (membrane separations, etc.) need to be quantified in order to implement a waste minimization strategy to reduce environmentally damaging air emissions from PUF plants.

NEXT STEPS

The Research Center For Waste Minimization And Management is in the process of forming a consortium of cooperative foam manufacturers, chemical suppliers, and relevant machinery manufacturers to develop the necessary design modifications for tunnel retrofit/isolation and collection of tunnel and post-tunnel emissions on one foam line. This represents the scale of development necessary to determine the feasibility of the concentration, recovery, and recycle strategy. The Center's approach offers a chance to address the environmental problems while maintaining worker safety and the existing continuous process and formulations. If the outcome of this demonstration indicates that even this approach is impractical, then this is critical information to the foam industry in discussions with regulatory agencies. The demonstration project at one plant would be delineated into the following three major areas of implementation with go/no-go decisions after each phase:

1. Design and install tunnel retrofit; modify tunnel exhaust system; and determine optimum tunnel exhaust concentrations for recovery of CH2Cl2.
2. Design methylene chloride recovery system; quantify specifications of recovered methylene chloride; produce a range of foam products with recycled methylene chloride and compare product qualities to analogous foams prepared with virgin methylene chloride.
3. Design and quantify vacuum recovery system for collection and recycle of post-tunnel losses of methylene chloride.

Each implementation phase would be subjected to cost and product quality analyses, quantification of actual reductions in air emissions, and measurements of worker exposure to ambient toluene diisocyanate and CH_2Cl_2.

ACKNOWLEDGEMENTS

The initial foam preparation technique, closed system apparatus, preliminary weight loss data, and weight loss data on insulated foams were conducted by Gertrude Raumann as a research assistant. Internal foam temperature measurements were performed by Scott Blaha, as part of a summer research project. Mass loss data on open and closed 1:1, 3:1, and 4:1 systems and the preliminary vacuum experiments were completed by Lisa Ashby and Maresa Williamson as summer research projects. Water-blown foams were prepared and mass loss data were completed by Allyson Bell as a research student. Measurements of volatile losses at the three plant sites and analysis of foam physical properties were done by Valerie Martin as part of her master's thesis. Special thanks go to the three manufacturing plants, Hickory Springs, Olympic Products, and Leggett & Platt for their participation, advice, and supply of raw materials.

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WASTE MINIMIZATION ASSESSMENT CENTERS

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ABSTRACT

In 1988, University City Science Center (Philadelphia, Pennsylvania) began a pilot project to assist small and medium-size manufacturers who want to minimize their formation of hazardous waste but who lack the in-house expertise to do so. Under agreement with the Risk Reduction Engineering Laboratory of the U.S. Environmental Protection Agency, the Science Center's Industrial Technology and Energy Management (ITEM) division established two waste minimization assessment centers (WMACs) at Colorado State University in Fort Collins and at the University of Tennessee in Knoxville. During the second program period of the project, a third WMAC established at the University of Louisville (Kentucky) has begun to conduct assessments.

Each WMAC is staffed by engineering faculty and students who have considerable direct experience with process operations in manufacturing plants and who also have the knowledge and skills needed to minimize hazardous waste generation. The waste minimization assessments are conducted at no out-of-pocket cost to the client. Several site-visits are required for each client served. The WMAC staff locate the sources of hazardous waste in each plant and identify the current disposal or treatment methods and their associated costs. They then identify and analyze a variety of ways to reduce or eliminate the waste. Specific measures to achieve that goal are recommended and the essential supporting technological and economic information is developed. Finally, a confidential report which details the WMAC's findings and recommendations including cost savings, implementation costs, and payback times is prepared for each client manufacturer.

This presentation will discuss results from the first period of this project.

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication.

WASTE MINIMIZATION ASSESSMENT CENTERS

INTRODUCTION

The amount of hazardous waste generated by industrial plants has become an increasingly costly problem for manufacturers and an additional stress on the environment. One solution to the problem of hazardous waste is to reduce or eliminate the waste at its source.

University City Science Center (Philadelphia, Pennsylvania) has begun a pilot project to assist small and medium-size manufacturers who want to minimize their formation of hazardous waste but who lack the in-house expertise to do so. Under agreement with the Risk Reduction Engineering Laboratory of the U.S. Environmental Protection Agency, the Science Center's Industrial Technology and Energy Management (ITEM) division initially established two waste minimization assessment centers (WMACs) at Colorado State University in Fort Collins and at the University of Tennessee in Knoxville. Each WMAC is staffed by engineering faculty and students who have considerable direct experience with process operations in manufacturing plants and who also have the knowledge and skills needed to minimize hazardous waste generation. During late 1989, a third WMAC at the University of Louisville was established.

During the initial period of this pilot project, each of the two WMACs conducted six assessments for small and medium-size manufacturers at no out-of-pocket cost to the client. Each client had to meet the following criteria:

- Standard Industrial Classification Code 20-39
- Gross annual sales of not more than $50 million
- No more than 500 employees
- Lack of in-house expertise in waste minimization

The potential benefits of the pilot project include minimization of the amount of waste generated by manufacturers, reduced waste treatment and disposal costs for participating plants, valuable experience for graduate and undergraduate students who participate in the program, and a cleaner environment without more regulations and higher costs for manufacturers.

All told, the measures recommended by the two WMACs in these 12 plants accounted for an identified cost saving of $1.28 million/year. This paper describes how the cost savings were found and identifies the specific measures designed to reduce waste formation and emissions from two of these plants. However, equally detailed accounts of the other ten plants could also be prepared.

METHODOLOGY OF ASSESSMENTS

The waste minimization assessments require several site-visits to each client served. In general, the WMACs follow the procedures outlined in the Waste Minimization Opportunity Assessment Manual, July 1988. The WMAC staff locate the sources of hazardous waste in each plant and identify the current disposal or treatment methods and their associated costs. They then identify and analyze a variety of ways to reduce or eliminate the waste. Specific measures to achieve that goal are recommended and the essential supporting technological and economic information is developed. Finally, a confidential report which details the WMAC's findings and recommendations including cost savings, implementation costs, and payback times is prepared for each client manufacturer.

RESULTS

PLANT No. 1 (SIC 2851)

This plant produces paints, coatings, stains, and surface-treating products at an overall rate of about 1.1 million gallons/year for regional distribution on a schedule of 2080 hours/year for 52 weeks. Its operations primarily involve blending and mixing of raw materials, followed by product testing and packaging and by cleaning of vessels and lines. Color separation in the product is obviously important, and each lot must meet a variety of other customer specifications.

Plant Operations

Individual lots of water-based and solvent-based paints are mixed in a variety of tanks from 200 to 1000 gallons' capacity. Ingredients for this initial step include (for water-based) water, latex, resins, extenders, and dispersed pigments. For solvent-based paints the materials are generally similar in type, but obviously solvent replaces water and latex, and the other new ingredients include plasticizers, tints, and thinners.

After batches are made up they are transferred to so-called let-down tanks, where additional water (or solvent), resins, preservatives, anti-foaming agents, thinners, and bactericides are added. Testing of batches encompasses at least color, viscosity, and gloss, and those lots which meet specifications are filtered and charged to cans for labeling, packaging, and shipping.

Waste Generation and Existing Waste Management Practices

The principal waste streams are the result of equipment cleaning, especially from water-based paints. For example, rinsing the let-down tanks ordinarily requires about 35 gallons of rinse water, but that value increases to 53 gallons if light paint is to be blended after a dark predecessor. The hazardous nature of water rinses is due to mercury from the bactericide in the paint.

In some instances, rinse water from the mixing tanks is held in 500-gallon tanks and used in the let-down tanks (instead of fresh water) to formulate future batches of water-based paint. The rinses are separated according to the color intensity of paint in the tanks from which they were derived. For example, rinses from white paint formulation amount to about 70% of the total, and they are invariably used again.

Waste rinses not used again are piped to holding and flocculation tanks, to which alum is added to lower the pH, in which some solid is precipitated by adding flocculant, and from which supernatant liquid is removed for re-use in other paint formulations.

Tanks used for solvent-based paints are rinsed with mineral spirits at a rate of about 5 gallons/400-gallon tank. These washings are sent off-site for recovery, followed by recycling or sale as fuel.

In addition to re-use of rinse water and recovery of solvent, this plant has adopted the following measures to reduce waste generation:

- Cleaning equipment before the paint dries and hardens.
- Eliminating hazardous materials, except for mercury in the bactericide added to outdoor water-based paint.
- Avoiding hazardous container waste by purchasing the bactericide in water-soluble bags which dissolve during paint formulation.
- Scheduling batch formulations so that light ones precede dark ones and thereby reduce the total volume of rinses.

- Reducing the inventory of raw materials to avoid degradation and spoilage and to assure high-quality product that can be sold, rather than low-quality paint which adds to the burden of waste disposal.

- Using bag filters to collect dust.

Waste Minimization Opportunities

Table 1 summarizes the principal sources of waste, their amounts, the management method applied, and the associated costs.

Table 2 offers a brief description of each recommended WMO (Waste Minimization Opportunity) and of current plant practice, together with savings and cost data. Considered individually, the three WMOs recommended could save over $22,000/year, which represents about 25% of current waste management costs. Each has a simple payback time less than one year.

PLANT No. 2 (SIC 3443)

This plant manufactures aluminum brazed oil coolers for use in heavy equipment. It produces approximately 59,290 units each year.

Manufacturing Operations

The raw materials used in the production of the oil coolers include aluminum in sheet and coil form, aluminum castings and extrusions, tubes, fittings, brackets, caution labels, and plastic plugs.

The following steps are involved in production:

- Shearing, punching, and forming operations to fabricate the oil cooler tanks, headers, air fins, sides, and oil turbulator fins.

- Degreasing of oil cooler tanks, headers, sides, fittings, and brackets. The solvent Chlorothene (95% 1,1,1 - trichloroethane) is used in an open-air, steam-heated vapor degreaser. The unit is equipped with a refrigeration unit which condenses Chlorothene vapor and minimizes evaporative losses to surrounding plant air.

- Recycling of spent Chlorothene to the degreasing operation using an on-site still. Chlorothene is continuously circulated between the degreaser and a steam-heated solvent recovery still. Still bottoms containing spent Chlorothene, water, and oil are shipped off-site as hazardous waste.

- Assembly of oil coolers.

- Brazing of assembled oil coolers to join the internal and external coil fin surfaces for enhanced heat transfer. The oil coolers are first preheated in a gas-fired oven at 1020° F for 15 minutes. They are then dipped into an electrically-heated molten salt bath containing a sodium chloride-based compound, lithium chloride, and aluminum fluoride for 1 1/2 minutes at 1128° F and dipped in a water quench tank. Sludge from the salt bath and quench tanks is disposed in the outdoor on-site sand filter bed. Solids remaining in the filter are landfilled on company property; water is fed to the settling pond and eventually discharged to a river.

- Cleaning of oil coolers to remove all residual salt, expose copper cells (which could cause corrosion failure), and condition metal surface prior to painting. The following steps are involved in the cleaning:

    - submersion in a 2% nitric acid bath (1-2 hour residence time)

- cold water rinse
- dipping in NaOH caustic soda etching solution
- hot water (102°F) rinse
- cold water rinse
- dipping in a 50% nitric acid bath
- 2 cold water rinses
- dipping in a chromic acid wash
- 2 de-ionized water rinses
- drying in a natural gas-fired oven

- Treatment of hazardous spent process solutions and contaminated rinse water streams. The liquids are treated in a neutralization tank with lime for pH control and flocculant to enhance removal of suspended solids. The solution leaving the tank is pumped to a clarifier which removes solids and allows filtered water to flow to the settling pond. A solids-rich stream is pumped to a sludge-thickener settling tank for secondary sedimentation. Supernate from the settling tank is transferred to the sand filter beds for final water removal before on-site landfilling of solids.

- Treatment of effluent from the chromic acid and de-ionized rinse water washes. These hazardous waste streams contain chromium in hexavalent form. The streams are treated to obtain a sludge containing less toxic trivalent chromium compounds. Several chemical agents are added to the waste to produce relatively insoluble compounds which are recovered on the sandfilter beds and disposed in the landfill. The liquid is pumped to the settling pond and is eventually released to the river.

- Painting of oil coolers. The coolers are dipped in a paint-filled tank, allowed to drip after immersion, and transferred to a spray booth for additional spray painting. Paint is collected on floor coverings (plastic sheet or cardboard) and in spray booth filters and disposed of daily in barrels which are sent to an off-site landfill.

Existing Waste Management Practices

The plant has taken the following steps in managing its hazardous wastes.

- The plant owns and operates a landfill for its private use.

- Chromium reduction from hexavalent to trivalent form is performed in-house.

- A refrigeration unit and a solvent recovery still have been added to the degreasing unit to minimize evaporative loss and liquid waste.

- The plant constantly monitors its waste-stream effluents and has installed its own hazardous waste treatment facility.

- Water-based paints are currently used.

- The plant has a designated professional staff person based at corporate headquarters who periodically visits satellite plant locations to provide assistance in both hazardous waste monitoring and management techniques.

Waste Minimization Opportunities

The waste currently generated by the plant, the source of the waste, the quantity of the waste, and the annual treatment and disposal costs are given in Table 3.

Table 4 shows the opportunities for waste minimization that the WMAC recommended for the plant. The waste in question, the minimization opportunity, the possible waste reduction and associated savings, and the implementation cost along with the payback time are given.

DISCUSSION OF RESULTS

The two plants described have annual waste management costs of $188,370 and the WMACs were able to recommend to them a series of cost-saving measures which add up to $359,980 per year. The savings total exceeds the aggregate waste management cost because, in one of the two plants, the measures recommended save more than the cost of waste treatment, disposal, and recycling.

For example, in plant No.2, only a $13,485 waste management cost is presently associated with paint-contaminated filters and cardboard and plastic sheets but elimination of the painting is estimated to save almost $60,000 per year. Typically, savings in raw materials costs of 25 to 80% can be achieved by the recommendations offered. It is not hard to see how this kind of savings can add up to more than the costs of waste management in some plants.

The cost-saving approach taken with these results is generally conservative, because the WMOs address only the avoidance of raw materials costs and the reduction of present and future costs associated with waste treatment and disposal. Not claimed are the savings related to: possible changes in emission standards, any liability incurred from waste management practices, and costs arising from employee health and safety problems. It should also be noted that each WMO identified is treated as an isolated individual measure and no consideration has been given to effects occurring because of interactions among WMOs.

The WMAC program is continuing to serve eligible manufacturers, and future results are expected to allow more generalizations about the amounts and types of industrial waste materials encountered in the nation's plants.

It seems reasonable to conclude from recent WMAC program experience that small and medium-size manufacturers:

- Have recognized many of their waste generation problems and have undertaken a variety of actions to address them.
- Are receptive toward practical quality assistance, offered in their plants objectively and competently, that can help them to choose cost-effective waste minimization opportunities over and above what they have been able to achieve on their own.

Acknowledgment

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TABLE 1. SUMMARY OF WASTE GENERATED (SIC 2851)

	WASTE TREATMENT		WASTE DISPOSAL	
WASTE STREAM	Amount	Cost	Amount	Cost
HAZARDOUS LIQUID WASTE				
A. Water-based Waste:				
Equipment cleaning by water washing	26,700 gal (Hg water and paint)	$3,740	26,700 gal off-site	$48,040
B. Solvent-based Waste:				
Equipment cleaning by solvent washing			27,200 gal (mineral spirits) off-site	$37,080
TOTALS	26,700 gal	$3,740	53,900 gal	$85,120

TABLE 2. SUMMARY OF WASTE MINIMIZATION OPPORTUNITIES RECOMMENDED (SIC 2851)

WMO No.	Present Practice	Proposed Action	Cost Savings
1	Water rinses remove paint from tanks and pipes	Install a pipe-cleaning system consisting of 3 different-sized foam plugs or "pigs" to be sent throughout the pipes by compressed air. Paint is thus forced from the lines and to the canning line filter. The use of water and amount of waste are lower. (This WMO is applicable to non-white paints.)	Estimated waste reduction - 1,780 gal/yr Estimated cost reduction - $11,110/yr Estimated implementation cost - $1,600 Simple payback - 2 months
2	About 15 gal solvent per batch of paint is drummed and sent off-site for disposal.	Use a solvent recovery system based upon distillation and ship the small amount of remaining solid to a hazardous waste disposal site.	Estimated waste reduction - 3,300 gal/yr Estimated cost reduction - $5,420/yr Estimated implementation cost - $4,950 Simple payback - 11 months
3	A bactericide containing mercury is being used in water-based paints.	Eliminate the bactericide from water-based interior paints and substitute an organic material. (This WMO is applicable to non-white paints.) There is no cost difference between these additives.	Estimated waste reduction - 3,100 gal/yr Estimated cost reduction - $5,580/yr Estimated implementation cost - none Simple payback - immediate

TABLE 3. SUMMARY OF WASTE GENERATED (SIC 3443)

Waste Generated	Source of Waste	Quantity Generated	Annual Waste Management Cost
Still bottoms containing spent, contaminated Chlorothene (95%-1,1,1-trichloroethane), water, and oil.	On-site solvent recycling still associated with the degreasing operation.	150 gal/yr	$4,650
Evaporation of Chlorothene.	Degreasing operation.	6,525 gal/yr	0(a)
Sludge containing compounds derived from the salt bath constituents, impurities from the baths, and contaminants on the products' surfaces.	Salt bath tank and water quench tank in the brazing process. The sludge is collected on the sand filter beds.	514,917 lb/yr	28,500
Sludge containing various solids from the treatment of the spent cleaning solutions.	Treatment process for spent solutions from the cleaning of the brazed product. The sludge is collected on the sand filter beds.	1,171,060 lb/yr	36,375
Sludge containing various compounds from the chromium reduction process.	Chromium reduction process. The sludge is collected on the sand filter beds.	88,943 lb/yr	16,500
Paint-contaminated filters and cardboard and plastic sheets.	Painting of product.	9,812 lb/yr	13,485

(a) Currently there are no waste management costs associated with the evaporation of Chlorothene.

TABLE 4. SUMMARY OF WASTE MINIMIZATION OPPORTUNITIES RECOMMENDED (SIC 3443)

Part I

Waste	Minimization Opportunity	Waste Reduction Quantity	Waste Reduction Per Cent	Net Annual Savings	Implementation Cost	Payback Years
Evaporation of Chlorothene from the degreaser unit.	Install a conveniently removable cover on the vapor degreaser tank to reduce evaporative losses. Cover the tank except during times when parts baskets are being lowered into or taken out of the tank.	3.263 gal/yr	50	$17.180(A)	$220	0.01
Still bottoms from the on-site solvent recycling still.	Reduce the amount of lubricants used during metal-working and the openness of machine work areas to decrease the amount of oil picked up by parts during processing, thereby minimizing the amount of degreasing required.	30 gal/yr	20	1.010(A)	290	0.3
Evaporation of Chlorothene and Chlorothene contained in the still bottoms.	Replace the vapor degreaser system with an ultrasonic cleaning system which utilizes biodegradable detergents.	6.600 gal/yr	99	20.450(B)	50.000	2.4
Sludge from the water quench tank in the brazing process.	Modify the procedure for dipping the coolers in the salt bath to minimize carry-over to the water quench tank. Achieve maximum salt removal by gently vibrating or shaking the parts baskets and subjecting the parts to a hot air blast.	23.171 lb/yr	4	20.520(C)	43.880	2.1
Sludge from the salt bath and water quench tanks in the brazing process.	Replace molten salt bath brazing with vacuum brazing. Vacuum brazing is suitable for 80% of this plant's products.	411.934 lb/yr	80	203.440(C)	720.640	3.5

TABLE 4. SUMMARY OF WASTE MINIMIZATION OPPORTUNITIES RECOMMENDED (SIC 3443)

Part II

Waste	Minimization Opportunity	Waste Reduction Quantity	Waste Reduction Per Cent	Net Annual Savings	Implementation Cost	Payback Years
Paint-contaminated cardboard and plastic sheets.	Reduce paint loss by installing a low-pressure air-jet system over the paint dipping area to blow excess paint downward into tank. Install an IR paint-drying lamp to prevent dripping when coolers are moved to the spray booth area.	2,180 lb/yr	22	4,350 (D)	2,490	0.6
Paint-contaminated filters and cardboard and plastic sheets.	Install an electrostatic spray paint system for application of the oil cooler second coat of paint in order to reduce overspray loss.	3,513 lb/yr	36	11,200 (D)	13,200	1.2
Paint-contaminated filters and cardboard and plastic sheets	Discontinue the practice of painting oil coolers which will be re-painted by the customer.	4,906 lb/yr	50	59,720 (D)	28,440	0.5

(A) Includes cost savings attributed to the avoided purchase of Chlorothene.
(B) Total savings have been reduced by the cost of detergents required.
(C) Includes cost savings attributed to the avoided purchase of salt bath constituents.
(D) Includes cost savings attributed to the avoided purchase of paint supplies.

LIABILITY AND BENEFIT SHARING FOR JOINT PRODUCTION ACTIVITIES INVOLVING RISKS[1]

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Abstract

This paper presents a model of joint production actitivities involving risks. The context for this problem includes generating, transporting and disposing of hazardous wastes. The economic agents involved are viewed as expected utility maximizers who contribute to carrying out a risky activity under asymmetric information. The problem is posed as one of providing incentives from one firm (the principal) to another firm (the agent) to undertake the risky activity and to invest in risk management in carrying out the activity. The principal provides such incentives through the contract form, payment scheme and ex ante agreed liability sharing rules for the potential liabilities occasioned by the actitivity. The framework of principal-agent theory is used to formulate the problem and to derive optimal risk sharing arrangements and levels of protective activity for the agent. Policy implications of the results and the relationship of these to several multi-party waste reduction and disposal problems are discussed.

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[1] This is a condensed version of the paper "Liability Sharing and Incentives" by the authors. The full paper is available from the Center for Risk and Decision Processes of The Wharton School.

1. INTRODUCTION

We have in mind the following context. One economic agent, the principal, delegates a risky production activity to another economic agent. A contract is negotiated covering liability sharing between the principal and the agent in the event an accident occurs in carrying out the activity. At the time the delegation contract is negotiated, the principal faces uncertainty regarding both the agent's safety characteristics and the agent's actions (e.g., the agent's investments in durable and nondurable risk management activities). The principal is interested in determining whether or not to undertake the activity and in designing a liability sharing contract which will provide proper incentives for the agent to exercise due care if the activity is undertaken.

In this economic environment, liability rules are crucial. If strict liability for the agent applies, the principal bears no risk in the event of an accident. In this case, accident liability will not be an issue for the principal, although the delegation contract may require higher payment to the agent to ensure the agent's participation in the project. On the other hand, if both the principal and the agent are jointly responsible for accident liability, the principal must take into account her share of the expected accident liability in determining transfer payments to the agent in designing the delegation contract.

Coase (1960) argued that liability rules and transfer payments are neutral to resource allocations if bargaining costs are negligible. However, when transaction costs are significant, or when there are information imperfections or legal impediments to bargaining contracts, the Coase theorem fails to hold (see e.g., Farrell (1987), Samuelson (1985)).

In the presence of information imperfections, designing the optimal delegation contract is complex. We will be concerned with contracts based on the agent's self-revealed safety characteristics as well as self-motivated safety effort, with liability sharing and remuneration based on these revealed characteristics. First, we will consider the case where protective activity by the agent is a choice variable, which would naturally depend on both the liability sharing rule adopted and the safety characteristics of the agent. This is the general case where both moral hazard and adverse selection are present. We then discuss the special case of adverse selection only, in which the level of protective activity undertaken by the agent is assumed fixed, but the accident proneness of the agent may vary and is unobservable by the principal.

When the principal does not observe actions of the agent, and she engages in negotiating contracts before the actions of the agent are undertaken, an improper contract offered by the principal will result in shirking of protective activity. The contract designed by the principal must provide proper incentives to the agent to undertake protective activity. Moreover, when the principal does not know the safety characteristics of the agent, the agent may have an incentive to misstate his safety characteristics to the principal during the bargaining process. Therefore, in bargaining about the appropriate liability sharing and ex ante compensation for the agent, the principal needs to design a mechanism which enables her to provide proper incentives to the agent for protective activity as well as to learn from the agent what his safety characteristics are. If the principal could observe the agent's actions and already knew his safety characteristics, then at least in a competitive market, the principal and the agent would engage in bargaining over the division of the economic surplus available through joint production activities. Depending on relative bargaining power, the principal might simply pay the agent an actuarial rate equal to the expected accident liability. Under these conditions, as argued by Coase [1960], liability sharing would not be an issue. Moreover, risky activities would only be undertaken if efficient to do so. As we will see, the existence of incomplete information, with accompanying adverse selection and moral hazard, has profound effects on this perfect information scenario.

2. ASSUMPTIONS

We assume that a principal is engaged in an activity which is risky and requires the services of an agent to co-produce the activity. A typical context might be a manufacturing firm which produces hazardous wastes which must be disposed of by a waste handling firm. In the model of interest here, the principal delegates the risky activity entirely to the agent to perform. In the event of an accident, there may be substantial losses, which will have to be paid for by either the principal or the agent, depending on ex ante agreed liability shares. We assume that the principal hires the agent from a market which determines the minimum payment the agent must be paid. Both the principal and the agent are risk neutral and have enough assets to finance accident liabilities; bankruptcy is excluded here.

We denote the total losses (in $'s) resulting from an accident by L and the principal's benefits from production by R; L and R are fixed. Denote by $P(a,t) \in [0,1]$ the probability of an accident where "a" is an action undertaken by the agent and "t" is the agent's type. We may think of t as representing the accident proneness of the agent, i.e., t represents agent-specific characteristics related to safety. The agent's action is chosen from a feasible set A. Denote by C(a,t) expenditures (in $'s) for production activities when the agent's action and type are a and t respectively.

For a given agent, the principal's problem is to determine whether to delegate the risky activity to the agent and how much to pay the agent if the activity is undertaken. We assume that the principal does not know the agent's type, but her uncertainty regarding the set of feasible agents' types is drawn from a continuous probability density function h(t) where $t \in T$, and $T = [t, \bar{t}]$. We assume that $h(t) > 0$ for all $t \in T$ and that its cumulative distribution function H(t) is common knowledge.

3. ADVERSE SELECTION AND MORAL HAZARD

The principal's objective is to design a contract that maximizes her expected payoff subject to incentive compatibility and individual rationality constraints on the agent. The individual rationality condition is that the agent's expected payoff under any feasible contract must ensure that the agent achieves his reservation utility level.

The incentive compatibility constraint we require is that the contract designed should induce the agent to reveal truthfully his actual type. Adopting the framework of the revelation principle (see Myerson (1979, 1981)), this constraint can be imposed without loss of generality. The "contracts" of interest here are defined in terms of a triad of functions $\{x(t),y(t),z(t) \mid t \in T\}$:

$$x(t)\colon T \rightarrow [0,1],\ y(t)\colon T \rightarrow [0,1],\ \text{and } z(t)\colon T \rightarrow \mathbb{R}_+,$$

where $x(t)$ represents the liability share for an agent whose declared type is t if the activity is undertaken with this agent, $y(t)$ represents the probability that an agent with declared type t will be contracted to undertake the actitivity, and $z(t)$ represents the payment from the principal to an agent with declared type t if the agent undertakes the activity. If a contract $\{x,y,z\}$ satisfies both incentive compatibility and individual rationality of the agent, it is assumed to be implementable.

In designing contracts, the principal announces a contract $\{x,y,z\}$, all of which contingent on the declared type of the agent. The agent then declares his type to be s (possibly misrepresenting his actual type t), and the specific contract $\{x(s),y(s),z(s)\}$ is then implemented. The agent then chooses protective activity "a", knowing the specific contract implemented, and the activity is executed.

Given the assumptions above, the expected payoff of the principal U under the contract $\{x,y,z\}$, when any agent chosen by the principal declares his true type and when the agent selects action $a(t)$, is described by:

$$U(x,y,z) = \int_{\underline{t}}^{\bar{t}} [R - (1-x(t))P(a(t),t)L - z(t)]y(t)h(t)dt. \tag{1}$$

The agent's expected payoff V from the contract $\{x,y,z\}$ is given by the following for an agent of type t who declares his true type to be s:

$$V(x,y,z,a,s,t) = [z(s) - x(s)P(a,t)L - C(a,t)]y(s) + \underline{V}(t)[1-y(s)]. \tag{2}$$

The principal's design problem is therefore characterized by:

$$\underset{x,y,z}{\text{Maximize}} \quad U(x,y,z) \tag{3}$$

$$\text{Subject to:}\quad (a,s) \in \operatorname*{Argmax}_{\substack{a\in A\\ s\in T}} \{ V(x,y,z,a,s,t) \} \qquad (t \in T)$$

$$\operatorname{Max} \{ V(x,y,z,a,s,t) \mid a \in A,\ s \in T\} \geq \underline{V}(t)$$

where $\underline{V}(t)$ is the reservation utility level of the agent whose type is t. With some manipulation (see Kleindorfer and Watabe (1990)), this problem boils down to an optimal control problem with a fixed endpoint, with V as a state variable and x and y as control variables as below.

$$\operatorname*{Max}_{x,y,V} \int_{\underline{t}}^{\bar{t}} \{[R-P(a(x(t),t),t)L-C(a(x(t),t),t)-\underline{V}(t)]y(t)-V(t)+\underline{V}(t)\}h(t)dt$$

subject to:

$$V_t(t) = -\,[x(t)P_t(a(x(t),t),t)L + C_t(a(x(t),t),t)]y(t)+\underline{V}_t(t)[1-y(t)]$$

$$V(\bar{t}) = \underline{V}(\bar{t})$$

$$0 \leq x(t) \leq 1$$

$$0 \leq y(t) \leq 1$$

where subscripts denote derivatives (e.g., $V_t = \partial V/\partial t$). The solution to the optimal control problem is summarized in Theorem 1.

Theorem 1: The optimal contract of the principal (x^*,y^*,z^*) is given by:

$$x^*(t) = 1 \qquad \text{if } P_tL \leq |\partial C_t/\partial x| \text{ for all } t \in T$$

$$\in (0,1) \quad \text{otherwise}$$

$$y^*(t) = 1 \qquad \text{if } R \geq P(a^*,t)L + C(a^*,t) + \frac{H(t)}{h(t)}(x^*(t)P_tL+C_t+\underline{V}_t) + \underline{V}(t)$$

$$= 0 \qquad \text{otherwise}$$

$$Z^*(t) = z^*(t)y^*(t) = [x^*(t)P(a^*,t)L + C(a^*,t) + \underline{V}(t)]y^*(t) + \int_{t}^{\bar{t}} [x^*(s)P_sL + C_s + \underline{V}_s]y^*(s)ds$$

Corollary 1: If the probability of an accident P depends only on the agent's action, that is, $P(a,t) = P(a)$, then the principal selects only strict liability for the agent; $x^*(t) = 1$.

4. ADVERSE SELECTION

This section specializes the above model to the case in which the functions C and P do not depend in any essential way on the agent's actions. This is the case of pure adverse selection. The following result follows from Theorem 1.

Corollary 2: If the functions C and P do not depend on the agent's action, then the principal's optimal contract entails no liability for the agent; i.e., $x^*(t) = 0$ $(t \in T)$.

5. POLICY IMPLICATIONS AND CONCLUSIONS

In this section, we consider the public policy interpretation of the above results. First, consider social welfare and efficiency. At the principal's optimal contract, expected total surplus (ETS^*) is given by:

$$ETS^* = \int_{\underline{t}}^{\bar{t}} \{[R - P(a^*,t)L - C(a^*,t)]y^*(t) + \underline{V}(t)[1-y^*(t)]\}h(t)dt. \tag{4}$$

This is equivalent to the expected social profit from joint production activities, if undertaken, plus the agent's reservation utility level, if the activities are not undertaken, weighted by the probability $y^*(t)$ of undertaking the activity.

If the principal's benefit R exceeds the expected social cost ($PL + C + \underline{V}$), it is efficient to undertake the activity. At the principal's optimal contract, however, efficiency is not always satisfied since Theorem 1 requires that the activity not be undertaken ($y^*(t) = 1$) unless the principal's benefit exceeds the expected social cost plus an "information cost" (equal to $(H/h)(x^*P_tL + C_t + \underline{V}_t)$) imposed on the principal (see $y^*(t)$ in Theorem 1). Thus, from a social welfare perspective, the optimal contract (x^*,y^*,z^*) is ex ante inefficient, a consequence of incomplete information.

Nonetheless, if the government were to provide subsidies equal to the information cost of the principal, then the activities would be conducted whenever her benefit exceeds the expected social cost, i.e. ex ante efficiency would be assured in this case. (This assumes that the government could costlessly obtain the agent's revealed type and was otherwise fully informed on the technology and other parameters required to compute the information cost). Note that, when informationally feasible, subsidies do not vaiolate incentive compatibility of the agent, because neither the principal nor the agent faces bankruptcy in our analysis.

Next consider liability rules. Our results indicate that there are three cases for the selected liability sharing for a contract. Under the coexistence of adverse selection and moral hazard, the principal chooses either joint liability or strict liability for the agent, as shown in Theorem 1. If the probability of accidents does not depend on the agent's type, strict liability for the agent is selected (Corollary 1), but under only adverse selection, the agent bears no liability at all (Corollary 2). It is clear that because bankruptcy is excluded, the selection of liability sharing rules will affect the expected total surplus, i.e., social welfare, only through $y^*(t)$ (see (4)).

Throughout the paper, neither the principal nor the agent is assumed to go bankrupt. This assumption is crucial to the incentive and social welfare results presented. Suppose that the agent is not a large firm, and will face the possibility of bankruptcy under strict liability borne by the agent. Then, liability sharing offered by the principal can result in the agent's bankruptcy. The above framework would have to be modified substantially to capture the incentival and welfare consequences of such bankruptcy. On the incentives side, the costs of bankruptcy to both the principal and agent need to be carefully modeled. So do the consequences for potentially uncompensated victims in the event of bankruptcy.

To illustrate, suppose that the activities are undertaken with an agent with a small asset base at risk to cover eventual liabilities. In the event of an accident and the agent's bankruptcy, there may exist uncompensated liabilities. In this case, expected total surplus as measured by (4) does not indicate the true measure of social welfare, since this excludes uncompensated accident liabilities which must be covered by either victims or a third party. If "third party" means other insurers, then it is possible that we would face the issues currently confronting Environmental Impairment Liability insurance in which incomplete information and small firm problems, together with regulatory uncertainties, have led to a complete collapse of the EIL insurance market. Representing these problems and regulatory remedies in an extension of the above framework is an important area for future research.

As a final point, we have assumed in this paper that the principal engages in negotiation with only one agent. However, it is quite often the case, especially in the areas of waste reduction and waste disposal, that a firm (e.g., a waste generator) faces negotiation with several firms in arranging for a team of agents to coproduce a jointly risky activity. Such multi-agent issues are an interesting area for future research.

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MANAGING A HAZARDOUS WASTE MINIMIZATION INVESTIGATION

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ABSTRACT

INTRODUCTION

United States Army policy is to reduce its generation of hazardous waste to lessen the life cycle cost of manufacturing and to minimize potential enviromental liability including worker exposure to hazardous materials. The Army's designated goal is to reduce its 1985 hazardous waste generation levels by 50% by the year 1992. To accomplish this goal, the Army Materiel Command selected the Production Base Modernization Activity to conduct hazardous waste minimization (HazMin) studies at selected Army facilities. The Production Base Modernization Activity through a contract with Day & Zimmermann Corp. and Science Applications International Corp. investigated six Army facilities to determine how hazardous waste is produced and then to recommend HazMin alternatives. This investigation focused on each facility's individual waste streams and their on-site hazardous waste treatment facilities. Waste streams included waste petroleum oils, paint sludges, plating wastes, etc.

METHODS

The HazMin study investigation is separated into three distinct phases: Phase I, quantification, involves the pre-audit determination of how many waste streams and what type of on-site hazardous waste treatment facilities exist. Phase II, qualification, involves the auditing of these identified waste streams and treatment facilities to gain a complete understanding of which raw chemicals are used, what chemical/mechanical processes exist, and what types and volumes of wastes are generated. Phase III, recommendations, involves the selection of the most appropriate HazMin reduction alternatives for each waste stream and each treatment facility.

SUMMARY

This paper will address HazMin audit procedures and review the challenges of managing a hazardous waste minimization study. Actual types of HazMin recommendations are discussed including capital projects, process changes, and encouraging management initiatives. Also provided are valuable lessons learned.

INTRODUCTION

The United States Army Materiel Command (AMC) has instituted a comprehensive program to reduce the generation of hazardous waste throughout its industrial base. The Army has established a goal of 50% reduction of its 1985 volumes by 1992. The hazardous waste streams which are involved in these efforts include propellant and energetics production waste and by-products, waste oils, waste solvents, painting and paint stripping, etc. In order to accomplish this reduction goal, a Hazardous Waste Minimization (HazMin) program encompassing a number of efforts is now underway. This paper discusses just one of these efforts, the HazMin investigations at six facilities. These include four Army Ammunition Plants, one Army Depot and one Arsenal.

The Production Base Modernization Activity (PBMA) was established in 1973 to provide centralized management of the Department of the Army's (DA) armaments, munitions, and chemical production base modernization program. This program includes all Army ammunition plants, arsenals, and government equipment located at contractor owned and operated facilities. The environmental aspects of PBMA's involvement with these industrial facilities, plus current environmental support to both AMC and DA, provided the necessary experience for managing this environmental project. This project was managed by PBMA and supported through its engineering services contract with Day & Zimmermann Inc., who retained the services of Science Applications International Corporation, to complete these investigations. This contract is a essentially a task oriented, competitively awarded contract where individual Statements of Work (SOW) are prepared and a firm fixed price is negotiated.

The completion of this HazMin study also benefited work which the Assistant Secretary of the Army for Research, Development, and Acquisition (ASARDA) is currently conducting. The purpose of the ASARDA study is to identify Army-wide opportunities for reducing hazardous waste generation throughout the materiel development and acquisition life cycle. The facility-level HazMin studies discussed in this paper have provided valuable data which assisted the ASARDA study team in their efforts.

PROJECT MANAGEMENT APPROACH

A key part of this HazMin effort is the detailed study of 6 Army manufacturing and maintenance facilities. This effort focuses upon how hazardous waste is generated at the facility production line level. These HazMin audits are intended to ultimately identify projects which can be completed either by funding specific capital projects, changing processes or encouraging management initiatives. These individual HazMin audits are organized into a three-phased approach. Phases II and III were initially modelled after the United States Environmental Protection Agency's "Waste Minimization Opportunity Assessment Manual" (Manual). AMC has adopted a similar waste reduction hierarchy as EPA with source reduction being preferred, followed by recycling and treatment technologies. This HazMin approach also includes the review of all on-site hazardous waste treatment systems. The primary goal of HazMin is source reduction, but in reality technological solutions to source reduction are not feasible for all the varied waste streams. The combination of investigating each hazardous waste generator and each hazardous waste treatment facility allows for a comprehensive HazMin audit.

The result of this approach is a complete facility hazardous waste database on each waste stream and each waste treatment system. Phase I identifies and quantifies these streams and systems. Phase II gathers current data regarding the various processes. The Phase III HazMin recommendations are then tailored to each facility's specific needs and allows HazMin to be introduced at a number of levels at a facility. A further explanation of each phase follows.

PHASE I - QUANTITATIVE INVESTIGATION

The intent of Phase I is to describe each waste generation process at the point where the waste is actually produced and to describe each on-site hazardous waste treatment facility. The purpose of Phase I is to produce an "order of magnitude" profile of an installation's hazardous waste generation . Data which is to be collected includes : raw materials , a description of the waste generation process, and the volumes for all waste streams. Examples of hazardous waste generators include paint booths, automotive shops, propellant and explosive lines, etc. See figure 1 for a typical example of the Phase I databases.

Building #	Raw Material	Process Description	Type Waste	Volume per year	EPA ID #
30	Motor oil	Vehicle Maintenance	Motor Oil	4700 Gal	x721
30	Batteries	Vehicle Maintenance	Sulfuric acid	220 Gal	D003
30	1,1,1 Tricloroethane	Degreasing	Tricloroethane	1200 Gal	F002
31	Rags	Boiler Maintenance	Oily Rags	50 KG	x721
60	Hydraulic Oil	Hydraulic vibrator	Hydraulic oil	240 KG	x726
94	Propellants and Explosives	Explosive desensitization	Explosive contaminated sludge	134 KG	D001

Figure 1, Phase I Database for Hazardous Waste Generators

Phase I 's hazardous waste definition included all waste petroleum oils even though currently only thirteen states include waste petroleum as a hazardous waste. Hazardous waste treatment systems were also considered a part of the HazMin investigation because : 1) they all generate hazardous waste and as such, meet the definition of a waste generator, 2) knowledge of these systems allows for a tracking of hazardous waste streams from their generation to their disposal, 3) the total elimination of hazardous waste generation at any facility is not practical with today's technology and associated costs. The possible improvement of these treatment systems would however, still support the HazMin goals of generating less hazardous waste for off site disposal. See Figure II for a typical example of this On-Site Treatment System database.

Building	Waste Treatment Facility	Waste	Volume Treated per year	EPA ID #	Contrib. Process	Building Source.
123	Oily waste system	Oils, oily sludge	10, 000 KG	D008	Forging, machine clean-up	123
456	Pink Water	TNT+ RDX wastewater	1000 Gal.	K047	Washdown	C-12, C-23, C-34
789	Open Detonation	Lead Azide	1400 KG	D003	QA / QC	098,765
012	Open Burning	Wet scrap pyrotechnic mix.	27,000 KG	K044	House-keeping	1,2, 3, 4, etc.

Figure II, Phase I Database for
On-Site Hazardous Waste Treatment Systems

Phase I was a requirement of the initial project management plan. It was believed that the complexity of the Army facilities necessitated a facility-wide hazardous waste profile before implementing the EPA Waste Opportunity Assessment Manual. These two databases, one for the generators and the other for the on-site treatment facilities, allowed for all the project participants to gain the same perspective on that facility's hazardous waste profile. Agreement on the number, type, location and processes involved was then reached. Phase I became the foundation which Phase II, the auditing, and Phase III, the recommendations, could then be confidently constructed.

PHASE II - QUALITATIVE AUDITING

The Phase I database allowed for a broad understanding of each facility's hazardous waste generation and treatment. The needed detailed information on each stream and system is gathered during Phase II. The outline used to gather this information mirrored the Manual's approach. The Phase II information goals were to complete as accurate a mass balance of each hazardous waste generator as possible. Details as to raw material purchases, process flows, waste types, and quantities, etc. were collected and analyzed. The method utilized to collect this data included interviewing shop personnel and plant environmental staff. The collected data was used to understand the hazardous waste generating process and to determine if potential HazMin recommendations were feasible within the scope of other production requirements.

PHASE III - HAZMIN RECOMMENDATIONS

Each of the six plants visited has an active HazMin Program as required by AMC. These AMC/PBMA studies were intended to provide additional technical support to the facility's HazMin plans. The use of an outside audit team can provide valuable new insights and serves to highlight the importance placed on HazMin by the Army. Although these studies are still in progress, valuable recommendations have been identified at each of the sites. HazMin recommendations identified fall into 3 major categories, which we have termed employee awareness, minor technical changes, and process/ procedural changes.

Within the "Employee Awareness" category, we have identified a number of areas where education, better housekeeping, and increased awareness would reduce quantities of waste generated. For example, we have identified areas where solid waste is placed in hazardous waste containers. Poor housekeeping procedures observed could result in spills of material generating significant quantities of clean-up wastes. We have also identified areas where a plant is overcautious in environmental matters. This results in increased costs which are not really justified, and may even have some negative environmental effects such as utilizing hazardous waste landfill space that is not really necessary.

"Minor Technical Changes" is another area where improvements can be made. Plants are substituting alkaline cleaners (which are non-hazardous) in some degreasing operations where 1,1,1 trichloroethane is currently used. On-site stills can be utilized for solvent reclamation. Filter presses can dewater sludges resulting in decreased volumes for waste disposal. Solvent contaminated and explosive contaminated rags can be washed. These are just a few examples of audit team recommendations or ideas that have already been implemented by plants.

"Process/procedual changes" can be costly to implement, and may need extensive documentation to prove their validity to plant managers and project officers. We are currently investigating whether changes to a pink water (TNT) treatment plant could reduce waste generation. It is possible that reducing the temperature of water entering the plant would allow for increased settling of materials and would decrease the amount of anthrafilt needed for filtration purposes. On explosive lines, conveyors and part holders may become contaminated with explosive materials. At one plant, ultrasonic cleaning utilizing freon is the method currently used for cleaning conveyors and parts, and we will investigate the use of steam clean-out procedures for this same purpose. At another plant, a mixture of solvent and lubricant is used to lubricate production parts. When the lubricant is depleted from the solvent carrier, perfectly good solvent is then disposed. We are investigating procedures to determine the amount of oil necessary to replenish the depleted solvent to meet the lubricating needs of the production line. These examples are in their initial phase of development and are only included here to give a general feel for the types of waste minimization recommendations being investigated.

LESSONS LEARNED

The following observations deal with experiences the authors had at these six Army facilities, all of which have over 100+ hazardous waste streams. These issues/ suggestions may aid those professionals who need to conduct HazMin investigations at similarly sized facilities.

1. Conduct a Phase I Investigation

Phase I provides an "order of magnitude" view of the entire facility before implementing EPA's Manual. Without a clear view of all hazardous waste streams, a thorough facility HazMin opportunity assessment cannot be accomplished.

2. Hazardous Waste Treatment Systems

HazMin should include an investigation of how to improve the on-site hazardous waste treatment systems. Although the primary goal of HazMin is source reduction, the reality of HazMin is that technological solutions for all the waste streams do not now exist. The ability to improve the efficiency of any on-site waste treatment system will translate into less waste leaving a facility.

3. Allow for Data Verification

The need for accurate data regarding raw materials, process operations, and types and volumes of waste produced is required for meaningful reduction recommendations. Typically, hazardous waste generation involves many people and not all the needed information regarding a hazardous waste stream is known by any individual. Therefore, collected data has to be reviewed by many people , not just the facility environmental staff, to insure that the information is complete and accurate. The HazMin investigation should recognize this fact and allow for purposeful delays between each of the three phases for verification.

4. Organizational Issues
The emphasis on organizational/personnel issues cannot be over stated. HazMin technical aspects involve a through understanding of chemical and mechanical processes which generate the waste(s). It has been our experience that the technical aspects require the participation of a well seasoned professional team. However, the personnel and management aspects are equally important . Management support, the cooperation of the facility's environmental staff and the line supervisors, are key factors for the successful completion of this project.

5. Manual Forms
The various forms which appear in the Manual are well organized and are written in a logical, useable format. As helpful as these forms are to engineers/scientists; they are, however, intimidating to non-technical people. These forms were modified for use in this project to allow for ease of completion by both the project participants and some waste generator supervisors who were not interested in reading or understanding what the questions really involved. Those professionals involved with conducting a HazMin investigation may want to prepare hybrids of EPA forms to forestall the reluctance of some process supervisors to complete them.

6. Institutionalize HazMin
Many operations at the plant are not amenable to HazMin measures by the audit team. Once a production line has been established, HazMin possibilities may be lost or may require large capital expenditures to modify an existing system. It is therefore critical that HazMin be incorporated as early as possible into the research and development and design process. Other limitations at a facility result from requirements to follow military specifications. For example, changes in paint from oil-base to latex materials cannot be recommended as this would violate an existing military specification. The ASARDA study recognizes this HazMin issue and is working through other HazMin projects to modify various military specifications to remove the hazardous constituents where feasible.

7. Ongoing HazMin
HazMin is a continuous process which must be constantly reviewed and evaluated. Changes in production, funding availability, technology improvements, and new environmental regulations all will impact upon reduction recommendations. This HazMin investigation has tried to incorporate both immediate and long-term recommendations based upon economic cost analysis. Some HazMin concepts will require research and development as well as pilot studies to determine their potential value and feasibility.

8. Avoid Temptation
In the course of preparing HazMin recommendations, the temptation exists to reduce waste volumes in any way possible. However, production line quality cannot suffer as a result of recommendations. Also, the temptation exists to reduce waste volumes in ways that may not significantly impact environmental quality. Examples of this are recommendations to dewater sludges and stabilize/fix certain waste streams. While useful for HazMin accounting purposes , these measures still result in the same amount of pollutants being generated. Another temptation is to ignore the waste streams which do not appear in waste manifests. One example is volatile organic compounds (VOC's) emitted directly to the atmosphere. A comprehensive HazMin investigation will assess this waste stream, and propose reduction recommendations.

9. MSDS Information

It is suggested that consideration be given to including HazMin recommendations on each chemical's Material Safety Data Sheet (MSDS). MSDS's are required to accompany all purchases of chemicals by Army procurement regulations. These sheets describe a host of chemical characteristics but neglect to add HazMin options. A HazMin section would help to remind personnel of possible options before sending the waste for disposal.

SUMMARY

The Army Materiel Command is actively searching for opportunities (in cooperation with the other services, industry, and academia) to reduce its generation of hazardous waste. A number of efforts to identify both Army-wide and individual facility HazMin opportunities are now underway. The building block for identification of target waste streams and processes is the database developed during the three phase HazMin audits. This audit allows for similar waste streams to be grouped together allowing for efficiency in selecting the most appropriate HazMin recommendations for that waste category. HazMin recommendations include specific capital projects, process changes, and encouraging management initiatives. The Army program provides valuable lessons learned for other large scale waste minimization efforts.

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IMPLEMENTING INCENTIVES: EXPERIENCE AND EXPECTATIONS

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"Waste minimization" (WM) has become "pollution prevention"---a term which has been forcefully incorporated in bills to make EPA a Cabinet department,[1] and implies reduction of residuals throughout the production cycle, not just at disposal. The term also confuses means and ends, since it implies that continued reduction is good *per se*. But the goal is defined reductions in risk or environmental impact. Reducing to zero is not an end in itself in a world of limited resources; if the goal cannot be stated or little reduction in risk or impact would result, there is no apparent justification to "prevent." Finally, the term implies new tensions between regulatory *means*, since prevention entails changes in behavior and debate is already rising over the best mechanisms---pollution fees, marketable permits, or the negative incentives of command-and-control regulation---to effect such change.

Regardless of whether prevention means more than a shift away from end-of-pipe controls to avoid intermedia transfers and diminishing regulatory returns---and regardless of whether it applies just to hazardous waste, to solid waste, or to air and water emissions as well---it envisions unprecedented changes in raw materials, products, production processes, and disposal practices. These changes will collide with the inherent limits of traditional regulation, requiring use of incentives for their successful implementation.

This paper first suggests why use of incentive approaches for pollution prevention will likely be incremental, even where

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1/ *See*, *e.g.*, H.R. 3847, 101st Cong. 2d. Sess. § 110, passed by House March 28, 1990 (requiring a new EPA Assistant Secretary for Pollution Prevention).

rules are being written on a clean slate. It then traces this country's considerable use of such approaches to transcend traditional regulatory limits---experience which will shape future applications. Finally, it distills some principles for implementing pollution prevention as that concept moves towards a reality difficult to foresee.

I. INCENTIVES AS SUPPLEMENTS

Incentive or market-based approaches will likely be used as supplements to current regulatory systems, not as alternatives or replacements. First, for most pollution this country is not writing on a clean slate. Detailed regulatory systems mandated and closely monitored by Congress already exist, and the power of the familiar cannot be overstressed. Neither industry, states or environmental groups, nor the public is prepared to scrap those systems for uncertain and potentially disruptive alternatives. However imperfect, they will stick with the devil they know.

Second, existing regimes are savage competitors against innovative alternatives. Regulatory systems are like natural ones---they have evolved to stable equilibria, and resist attempts to push them in different directions. Less often noted are the reasons for such competition, which range from asserted ease of enforcement ("is the required equipment installed?") to fears that government jobs will be transformed. The most powerful of these reasons is the fact that the traditional approach has produced large environmental gains, for costs that have mostly been hidden. Any alternative which seems to erode such gains in the name of efficiency will be rejected. Incentives must first be justified on environmental grounds---as ways to preserve or extend these gains. Only a hybrid system, in which incentives supplement direct regulation by addressing specific, acknowledged shortfalls in securing further progress, is likely to do that.

Third, one trend on Capitol Hill is strongly in the opposite direction---towards more detailed mandates which seek to limit both Agency discretion and industry compliance flexibility. E.g., the 1984 amendments to RCRA progressively banned all solvents, chemicals and other wastes listed or characterized as hazardous from disposal even in properly permitted double-lined landfills, unless EPA promptly issued national technology-based standards requiring pretreatment to "best demonstrated technology" (BDAT) levels for each specific waste disposed in such facilities. Even pending clean air bills which incorporate sweeping incentive mechanisms feature stringent reductions and bristling commands---a connection which is not accidental.

Fourth, much Congressional effort has been spent buffering the effects of environmental policy---in assuring there are not too many big losers too soon. Yet pure incentives approaches are intended to produce large groups of winners and losers very rapidly---by efficiently "internalizing pollution costs" or "making polluters pay." Moreover, as acid rain debates demonstrate, many of these losers are likely to be clustered in the same Congressional districts. Thus, the "pure" approach does not stand much political chance.

Finally, past experience with incentive approaches will critically shape both future approaches and industry's response. E.g., constraints that make it difficult to use emissions trades for cost-effective compliance with current smog rules will discourage investment in surplus SO_2 reductions for acid rain. Even for pollution prevention a clean slate may be hard to find: beyond current incentives to reduce created by Superfund or tort liability, explicit incentives for process or product reformulation to escape the Air Toxics Title of pending Clean Air bills mean that prevention has already arrived.

II. LIMITS OF TRADITIONAL REGULATION

The problem is no longer large uncontrolled steel plants or utilities susceptible to standard engineering solutions. The stresses of dealing with the remaining universe, combined with budget shortfalls, trade deficits, and concerns over international competition, have faced regulators with the structural constraints on direct regulation:

- poor agency information about further feasible ways to control the thousands of diverse, changing products and processes that contribute most remaining pollution;

- soaring control costs, estimated by EPA to have exceeded a half-trillion dollars since Earth Day 1970 and now run $80 billion per year, not counting state laws, recordkeeping and reporting (e.g., SARA Title III) or opportunity costs;

- slow government response to new knowledge and rapidly-changing industrial circumstances through centralized rules tailored to individual processes or chemicals. Such rules require volumes of feasibility data, take years to complete, and often freeze past control technologies in place rather than stimulating new ones;

- little motivation for regulated emitters to do or disclose more than the minimum required (or unregulated emitters to disclose anything), since disclosure offers no benefits while making them targets for further regulation; and

- the "pollution problems of the 1990's": filling stations, farms, commuters and millions of other small dispersed sources of smog, runoff or groundwater contamination whose effective control often turns on local or site-specific factors, land use, or lifestyle changes; and regional or global problems caused either by hundreds of dispersed activities involving products rather than classic pollution (stratospheric ozone depletion), or by large controlled sources whose further direct control often means new ways of doing business and invokes vicious regional disputes (global warming or acid rain).

Such problems already dominate the environmental universe, and are not very amenable to centralized regulation or enforcement. Whether the incentives are financial, informational or technical, only a shift from regulation towards incentives can begin to overcome them by better matching individual private interests with environmental goals.

III. EXPANDING EXPERIENCE

In response EPA and the Congress have embraced or begun seriously exploring a broad range of incentive-based approaches. EPA's Final Emissions Trading Policy (51 FR 43814; Dec. 4, 1986)---which set federal rules authorizing emitters to create, store ("bank") and substitute inexpensive "extra" emission reductions for costly required ones---is merely one example. But because this "Bubble" policy was the first, has been thoroughly tested, and provided the base for broader applications, it is worth noting that it has saved American industry nearly a billion dollars over the cost of uniform stack-by-stack controls, with equal or better environmental results; balances flexible compliance with environmental integrity through stringent safeguards against "non-surplus" reductions, adverse ambient effects or incidental toxics increases; provides needed safety valves allowing adjustment of national rules to site-specific conditions; and protects sources that bank or trade against loss of credits if further reductions to meet health standards are required. Moreover, the central issue it resolves---how to construct an objective, predictable "baseline" which fairly measures "extra" reductions without penalizing early ones or crediting those that "would have happened anyway" through routine compliance or business decisions---is crucial for any use of incentives. Such certainty is essential where sources are asked to invest in extra reductions, and show they have made them.[1]

A short list of related initiatives might include:

- EPA's NSPS Compliance Bubble Policy (52 FR 29046; Aug. 4, 1987), which expressly authorizes emissions trades between different "new facilities" to meet technology-based New Source Performance Standards (NSPS). The first approved NSPS bubble was estimated to save a single utility station up to $22 million annually over the cost of conventional compliance, with about 2000 tons per year additional reductions in SO_2.

- EPA "Netting" Guidance (Feb. 27, 1987) giving states broad discretion to allow plantwide bubbles that encourage modernization without cumbersome "new source review" (NSR). Past "netting" transactions may have saved at least $5 billion over the costs of conventional NSR, without adverse air quality effects. See Hahn & Hester, "Marketable Permits: Theory and Practice," Ecology Law Quarterly, Vol. 16 No. 2 (1989).

- EPA's Stack Height Policy authorizing utilities required to reduce SO_2 emissions under tall stack rules, to make such reductions through statewide bubbles based on total loadings. (53 FR 480; Jan. 7, 1988). The final Policy selected the least constrained options; opened the door to bubble credits from Least Emissions Dispatching (under which utilities direct more generation to lower-emitting rather than lower-cost facilities); and was estimated to save affected sources as much as 60% of compliance costs, with nearly 50,000 tons per year more reductions.

- Lead Phasedown Trading which effectively implemented a nationwide marketable permit system, based on ordinary business records, for refiners who reduced average lead content of leaded gasoline below a shrinking EPA limit. The approach yielded "lead reduction credits" which were sold or bought by most of the industry; accelerated a 90% reduction of lead in gasoline while avoiding risks to small refiners and gasoline supplies; and saved several hundred million dollars over the cost of uniform compliance at each refinery. See, Hahn & Hester, supra; 50 FR 13116 (April 2, 1985).

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[1] See, e.g., Levin, "Statutes and Stopping Points: Building a Better Bubble at EPA," Regulation (March/April 1985). See also, Levin & Elman, "The Case for Environmental Incentives," Environmental Forum (Jan./Feb. 1990); "The Clean Air Act Needs Sensible Emissions Trading," Id. (March 1986).

- CFC permits to reduce stratospheric ozone depletion. U.N. protocols mandating a freeze and 50% phasedown in manufacture of these substances provide a continent-wide bubble for EEC countries and transboundary bubbles for others. EPA is implementing this first global regulatory effort through a system of marketable phasedown permits for CFC manufacturers and importers, allocated by historical production factors. Proposed supplementary fees to remove windfall profits have been superseded by Congress' first-ever environmental excise tax on these substances. See Levin & Elman, supra.

- Mobile source trades. EPA has long allowed use of emission reduction credits from mobile sources to meet stationary-source requirements. 51 FR at 43834 (April 7, 1982). It has also authorized use of fleetwide bubbles to comply with truck emission standards under the Clean Air Act, saving an estimated several hundred million dollars per year over the costs of engine-by-engine compliance (see 50 FR 10606 (March 15, 1985)), and recently proposed interfleet, multiyear trading among different engine makers to expand these effects. 54 FR 22652 (May 25, 1989).

- Risk Bubbles. In 1986 the Conservation Foundation proposed authorizing EPA to approve up to 10 applications waiving compliance with traditional regulatory requirements if applicants showed under specified criteria that significantly greater risk reduction would result from alternative actions. The approach, meant to use existing rules as an engine for better knowledge and risk reduction, has effectively been included in EPA's draft pollution prevention bill (March 15, 1990 draft, § 203).1/

1/ Similar developments include: expanded ability to use emissions credits from past shutdowns without EPA review, 54 FR 27274, 27290 (June 28, 1989); plantwide trades to meet effluent guidelines, 49 FR 21024 (May 17, 1984); interplant trades to meet ambient water quality standards, 40 CFR § 130.2(1), 130.7 (1989); point/non-point source trades to reduce nonconventional or toxic loadings, EPA/OW, Draft Final Guidance: § 304(1) of the Clean Water Act, § IV.C.d.2. (Sept. 1987); differential user fees for pesticide registrations, see 51 FR 42974 (Nov. 26, 1986), 53 FR 19108 (May 26, 1988); a pending measure to automatically phase out risky chemicals as safer substitutes become available, see Memo, "Proposed 'Safer Pesticides' Federal Register Notice," D. Campt, Director, OPP/EPA, to J. Moore, AA (OPTS), (June 17, 1987); and use of wetlands mitigation banks to reclaim ecological values at Superfund sites or preserve them at others. See Memo, "Wetlands Mitigation Banking," R. Hanmer, Acting AA (OW) to L. Fisher, AA (OPPE) (May 1, 1989).

- The new Clean Air Act, which features a national trading/banking/auction system of true marketable permits for SO_2 credits to achieve a 10-million-ton annual reduction in acid rain precursors for roughly half the cost of plant-by-plant controls, but may also envision plantwide bubbles to meet new air toxics requirements, plus broad regional trades to meet mandates for smog reduction, clean cars and fuels. The Act represents a quantum leap in Congressional and environmental-group support for incentive approaches (as well as in industry reliance on them for flexible compliance), and has already accelerated their use elsewhere.[1/]

- Recycling Tickets. EPA's 1986 Report to Congress on Waste Minimization suggested that if further controls on waste generation become needed, a route preferable to WM standards or bans on waste streams might be tradeable phasedown permits which let market forces determine the location and pace of individual reductions. Under a similar approach developed by EPA to address the millions of gallons per year of used engine oil that are dumped due to negative prices, virgin oil refiners would need tickets representing one gallon of properly recycled oil for every four new gallons produced; tradeable tickets would be generated by oil recyclers or rerefiners; and recycling could yield substantial returns from these tickets' sale.

The original approach was meant to help finance recycling facilities by allowing them to generate a double revenue stream (from sales of tickets plus recycled oil). But it could also have endangered lube oil supplies if the recycling ratio was set too high or the recycling market could not promptly respond. Pending House and Senate bills to establish similar ticket systems would correct this problem by imposing on producers or importers of virgin oil, newsprint and tires an escalating recycling mandate (rather than a production constraint), which can be met either by self-recycling or purchase of covering tickets from downstream recyclers. See, e.g., H.R. 3735, § 208 (used oil); H.R. 3483 (newsprint); H.R. 4147 (scrap tires). The tire bill attempts to address the fact that scrap tires cannot be recycled into new virgin product

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[1/] See, e.g., Project 88: Harnessing Market Forces to Protect Our Environment: Initiatives for The New President, A Public Policy Study Sponsored by Sen. T. Wirth [D-Col] and J. Heinz [R-Pa] (Dec. 1988), advancing a comprehensive bipartisan program of which acid-rain trades were only the first step.

through a differential credit system aimed at drawing scrap tires towards their highest-value secondary use.[1]

These bills would shift responsibility to producers for minimizing waste caused as a result of their products. They provide suggestive models for aspects of pollution prevention discussed below.

IV. TRADEABLE POLLUTION PREVENTION PHASEDOWN PERMITS: ANOTHER ROUTE?

Clearinghouses for further WM seem unlikely to provide incentives to use that data beyond those already created by landfill bans, potential Superfund/tort liability, and rising tip fees.[2] Indeed, to the extent downstream liabilities cannot be quantified to overcome internal company "hurdle rates" for returns on additional WM investment, such data may not be used at all.

Two major models currently seek to address this issue: proposals for (a) mandatory WM audits and reduction plans, applicable to facilities that must file annual Toxics Release Inventory (TRI) reports under SARA Title III and enforceable by public disclosure; and (b) per-pound or differential fees, imposed either on facilities' TRI inventories or on new materials ending as solid waste (*e.g.*, plastic resins). There are arguments for both. But mandatory WM *plans* turn on companies' good-faith execution of WM audits, could promote risky substitutes because they cover only a small segment of the HW universe, and seem likely to generate a flood of paperwork seldom reviewed. Meaningful *fees* require detailed data on industry cost curves and total releases; could not be set high enough to affect behavior because new materials represent only a small slice of most finished products; and imply reductions to zero regardless of risk or location. Moreover, even a small fee imposed on the last slice of allowable pollution -- meant to move those assessed in desirable directions and get company management involved -- ducks the issue of what reduction goal is appropriate, and could undermine valuable behavior if, e.g., materials being recycled are also taxed.[1]

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[1] *See* Levin, *Written [Testimony], Hearing on Scrap Tire Management & Recycling Opportunities*, House Small Business Subcommittees on Environment & Labor etc. (April 18, 1990).

[2] *See*, *e.g.*, Levin, "The Trash Mess Won't Be Easily Disposed Of," *Wall Street Journal* (Dec. 15, 1988), p. A 18.

Tradeable phasedown permits for solid or HW generators based on historical waste generation could overcome many of these problems, link means with ends, and force decisions on how much prevention is appropriate. While what follows deals with SW involving only reductions in volume, the same implementation issues apply to HW, since "toxic hotspot" concerns are reduced by the fact that all HW generated remains subject to RCRA management rules.[2] Those issues include who to permit; how to measure creditable reductions; whether and how to use "trade ratios" to encourage reduction of riskier substances; how to minimize such perverse effects as use of riskier nonpermitted substitutes; and how to construct safety valves that will allow the permit system to be expanded or tightened without penalizing those who have already participated. Past experience suggests numerous answers.

Suppose EPA, instead of mandating reductions by generators, were to issue tradeable permits requiring municipal/private landfills to receive 2% less waste/year for the next 10 years, beyond pending 25% recycling goals. A city like Seattle which recycles 40% would get both assets to sell and a double revenue stream (from sale of credits plus extended landfill capacity). A city like New York which bought those credits to cover excess landfilling would pay a double penalty, since it both exhausts capacity more rapidly and pays Seattle to do so. This approach would mirror the credit system for used oil, with responsibility imposed on the "end-user" rather than the producer. It raises classic questions, not least of which is how to credit landfills that shut down. But it could also reward innovative SW management steps and provide funds for such measures, while strengthening recycling and recognizing that the test is reduction of overall environmental impacts, not waste.

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[1] Despite their attraction as potential revenue-raisers and possible use as a "Clarke tax" to encourage more accurate pollution reporting, see, e.g., "Apple-Pie Aspect of Environmental Taxes Draws Proponents . . .," Wall Street Journal (May 21, 1990), p. A 30; "Truth or Consequences," Sonstelie & Portney, Journal of Public Policy Analysis, Vol. 2 No. 2 (1983), fees represent a declining revenue stream if they work properly, and could distort other environmental programs by diverting industry choices to counterproductive ends.

[2] Cf., e.g., S. 1113, 101st. Cong. 2d Sess. Title III, § 305, tacitly authorizing plantwide bubbles by SARA § 313 facilities required to reduce total hazardous-substance releases to no more than 5% "of production throughput" of such substances within 10 years. Facilities reducing more or earlier could be allowed to sell credits nationwide to those whose reduction costs were much higher.

In implementing such approaches, some do's and don't's drawn from past experience should be kept in mind. The *do's* include: (1) keep the approach *small* so bugs can be worked out, but address the ability to expand it up front (*e.g.*, by incorporating "trade ratios" for dealing with incidental toxics). Note that "small" can refer either to the universe of sources covered, the number of pollutants covered, or the initial size of the reduction required; (2) keep it *simple* and *easy to use*; (3) keep it *predictable*, so potential preventers feel comfortable they won't be penalized for their actions and can make rational investment decisions; (4) *get it out on the street* to be used, so specific applications can provide vehicles for midcourse corrections and dispel regulatory fears; (5) *include safety valves* that allow for such corrections and for inevitable evolution, without penalizing those who have already participated.

The *don't's* include *avoid*: (1) *over-loading* incentive approaches with constraints aimed at achieving other program or environmental goals; (2) *defining the experiment to fail* by seeking optimality in credit markets or reductions to zero, both of which are unrealistic and divert resources from tasks based on sensible expectations; (3) the belief that *every problem will be solved by mandated technology* or reduction requirements; (4) *discouraging new technologies* (*e.g.*, by treating potential recyclables as pollution); the belief that *government has all the answers* and knows "how to do it" better, or that *states are incompetent and spineless*, therefore not to be trusted; and (5) the belief that incentive approaches (or conventional rules) must be written to treat all industrial managers like criminals by precluding every chance of abuse, rather than being written to be usable and leave abusers to enforcement.

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IGT BIOPROCESS TECHNOLOGY DEVELOPMENT EFFORTS FOR THE PRODUCTION OF CLEAN FUELS

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The Institute of Gas Technology (IGT) has been developing bioprocess technologies for the production of clean fuels since 1970. The scope of these efforts has ranged from the laboratory through pilot plant using a variety of feedstocks: waste, biomass, peat, coal, oil shale, oil and gases. Some of the recent and ongoing research efforts are cleaning coal, char, oil shale, and gases by microbial removal of sulfur and microbial solubilization of coal to liquid fuels. Development of such pollution preventive bioprocess technologies involves the integration of microbial, physical, and chemical systems and requires a concerted effort by engineers and scientists.

This paper discusses the research being conducted at IGT in the area of microbial desulfurization of coal, char, sour natural gas and Eastern oil shale and in the area of microbial conversion (solubilization/gasification) of coal to liquid and gaseous fuels. The paper also highlights the issues and challenges facing the engineers and scientists in developing such technologies.

INTRODUCTION

The Institute of Gas Technology (IGT) has been developing bioprocess technologies for the production of clean fuels from various feedstocks that include biomass, waste, coal, oil shale, and gas since 1970. Researchers at IGT have developed bioconversion processes with improved yields and rates for the gasification of both marine and land biomass. The marine biomass work included studies with untried biological species and the development of advanced process concepts for kelp conversion through anaerobic digestion. The land biomass involved a similar evaluation of herbaceous and woody species for energy production by biological and thermochemical gasification.(1-4)

IGT researchers have been investigating an innovative anaerobic digestion concept at a pilot-scale experimental test unit (ETU) for the conversion of wastes generated in or around a typical community in the United States. The 160-ft^3 digester, located at Walt Disney World, Florida, was successfully operated on blends of water hyacinth plants and primary sludge.(5)

IGT has patented a two-phase anaerobic digestion process for high-rate, high-energy-efficiency and high-stability conversion of biomass and organic wastes (municipal as well as industrial) to high-methane-content fuel. Work has been conducted on the conversion of municipal solid waste and sewage sludge to methane by the two-phase digestion process in IGT's BIOGAS® process that has the flexibility to combine pre- and post-treatment schemes with two-phase digestion for conversion of municipal solid wastes to methane.

IGT has been conducting research since 1980 in the areas of microbial desulfurization of coal and biocatalytic gas desulfurization and since 1986 has been conducting research in the area of microbial solubilization and gasification of coal to liquid and gaseous fuels.

This paper reviews IGT research efforts in the area of microbial desulfurization of coal, char, oil shale and sour natural gas and in the area of microbial conversion (solubilization/gasification) of coal to liquid and gaseous fuels.

RESULTS OF DISCUSSION

MICROBIAL COAL DESULFURIZATION

Under a research program funded by U.S. DOE/PETC on microbial coal desulfurization, IGT has succeeded in developing bacterial cultures that specifically cleave carbon-sulfur bonds in a range of model organic compounds. Gas chromatography/mass spectroscopy (GC/MS) analyses have indicated that these cultures are capable of removing the sulfur from the organic substrates while leaving the carbon intact. These cultures are the mixed culture IGTS7 and the pure culture Rhodococcus rhodochorous IGTS8 (the active component in IGTS7). In addition to removing the sulfur from model organic compounds, these cultures also removed the organic sulfur from Illinois No. 6 coal.(6) A sulfur-by-type analysis of the coal showed that 84% of the organic sulfur was removed. These samples were analyzed by an ASTM procedure in which the organic sulfur content is calculated. To ensure that accurate and reliable data were obtained, samples were also analyzed by a modified ASTM procedure, in which the organic sulfur content is actually determined, and by the electron microbeam method for the direct determination of organic sulfur. Analysis of the samples by the modified ASTM procedure showed a decrease in the organic sulfur of 91%, from 2.25% to 0.205%. An analysis of the samples by the electron microbeam method revealed an 80% decrease in organic sulfur. These results are all in agreement and therefore confirm the microbial removal of the organic sulfur from coal.

To make a bioprocess technology economically attractive, the rate and efficiency of microbial desulfurization needs to be improved. Such an improvement will require biological, thermal, physical and/or chemical approaches. Research is currently focusing on enhancing coal biodesulfurization by genetic modification which involves, identifying, cloning, and enhancing the expression of the genes responsible for the cleavage of carbon-sulfur bonds. The availability of organo-sulfur compounds in coal to microorganisms may also be a limiting factor in microbial coal biodesulfurization. Recently CRSC has announced the funding of two one-year studies at IGT to determine if the rate and efficiency of biodesulfurization is improved when the coal has been modified by thermal, physical, and/or chemical methods. It is believed that the availability of organo-sulfur compounds to microorganisms can be increased by increasing the pore size distribution through a thermal, physical, and/or chemical process. A team of chemical engineers and biologists will be working on these projects.

MICROBIAL CHAR DESULFURIZATION

Under a research program funded by U.S. DOE/METC, IGT is examining the mild thermal gasification of Illinois coal to fractionate the coal to produce liquid products such as benzene, toluene, creosote, etc. The by-product of this process is char. To make this process more attractive, efforts are being made to significantly enhance the yield and quality of coal-products such as char. The char produced still retains a relatively high volatile matter content and heating value; however, the sulfur content is too high to meet the U.S. Clean Air Act Standards for sulfur emissions and therefore must be reduced before it can be utilized as a clean fuel. IGT conducted research to examine the ability of the mixed culture (IGTS7) developed for coal desulfurization to remove organic sulfur from char and demonstrated microbial desulfurization of char. In the presence of IGTS7, 60% of the organic sulfur was removed. Future bench scale studies are planned to optimize the system. It is anticipated the mild gasification of coal to produce value-added chemicals combined with microbial desulfurization of char will result in a technology that will produce clean products for both the chemical and energy industries.

Another area of research that IGT is involved in, with the idea of developing a clean coal conversion technology, where microbial systems may have application is in the microbial conversion (solubilization/gasification) of coal to liquid and gaseous fuels.

MICROBIAL COAL SOLUBILIZATION

Research on microbial solubilization of coal generally uses pure cultures of microorganisms, mainly fungi and actinomycetes. The majority of these organisms are lignin degraders.(7-12) Under an internally funded program, IGT isolated mixed cultures IGTB1 and IGTMx15 that were able to solubilize coal.(13)

The ability of the organisms to solubilize coal seems to be dependent upon the oxidation state of the coal.(12) Low rank coals such as lignite, which have a higher oxygen content than high rank coals, are microbially solubilized. Low rank coals that have been chemically pretreated with oxidants such as nitric acid or hydrogen peroxide are even more susceptible to microbial solubilization. Studies at IGT examined the role of oxygen content on solubilization and confirmed other researchers observations that the microbial solubilization of coal is dependent upon the oxidative state of coal.

The demonstration and confirmation by several researchers that oxidized coal can be microbially solubilized has led efforts to be directed towards elucidating the mechanism(s) involved in the solubilization process.(8-9,14-15) Researchers suggest that either an extracellular process, an alkaline formation by microorganisms, or a metal-chelating agent produced by the microorganism is involved. This research determined the mechanism involved in coal solubilization. The mechanism of solubilization for the cultures IGTB1 and IGTMx15 was alkaline formation.

Preliminary characterization of products from microbial coal solubilization by gas chromatography/mass spectroscopy (GC/MS) as well as Fourier transform infrared spectroscopy (FTIR) indicated the presence of humic acid type compounds. Future characterization of the products are needed to identify their market value.

MICROBIAL COAL GASIFICATION

Because it has been generally thought that coal is resistant to anaerobic decomposition only recently has there been any research in microbial coal gasification. Researchers have now demonstrated the direct conversion of coal to methane.(16) The microbial production of methane was observed in samples containing coal and solubilized coal products in the presence of complex nutrients such as yeast extract. Short chain acids and alcohols were identified as the intermediary metabolic products that accumulated during the bioconversion of coal to methane.

IGT's approach to biogasification is a two-stage process concept.(17) Stage I is aerobic and involves combined alkaline-biocatalytic oxidation and solubilization. Stage II is anaerobic and involves the anaerobic conversion of the products generated from Stage I to methane. Bench-scale studies are underway to test the feasibility of this microbial solubilization/ gasification system.

Besides the production of methane in this anaerobic biogasification system, H_2S would also be generated. IGT is conducting research in the area of microbial removal of H_2S from such gas streams and from sour natural gas.

MICROBIAL REMOVAL OF H_2S

IGT has identified two microorganisms Thiobacillus thioparus and Chlorobium limicola forma thiosulfatophilum that can metabolize H_2S. Preliminary research conducted at IGT has demonstrated that the aerobic, nonphotosynthetic, chemolithotrophic, organism Thiobacillus thioparus, is capable of converting H_2S to elemental sulfur, which is excreted to the medium by the bacteria and, therefore, could be separated from the bacterial cells and medium. Analysis of elemental sulfur production indicated that 78% of the H_2S was converted to sulfur. Future bench-scale studies are planned to optimize the Thiobacillus thioparus system for removal of H_2S and conversion to elemental sulfur.

IGT has patented a process utilizing Chlorobium limicola forma thiosulfatophilum for removal of H_2S.(18) Research has demonstrated that the anaerobic, photosynthetic autotrophic organism, Chlorobium limicola forma thiosulfatophilum is capable of converting H_2S to elemental sulfur which is excreted to the medium by the bacteria, and, therefore could be separated from the bacterial cells and medium.(19-21) Analysis of elemental sulfur production indicated that >90% of the H_2S was converted to sulfur. These organisms are being proposed for application in a primary process to remove H_2S from sour gas or in a secondary process to cleanup the tailgas resulting from a conventional physical/chemical gas cleanup operation.

MICROBIAL OIL SHALE DESULFURIZATION

One of the many processes that release H_2S into the environment is oil shale retorting. Under a program funded by the U.S. DOE, IGT is conducting a research program to develop a pressurized fluidized bed hydroretorting (PFH) process for the production of oil from Eastern oil shale. During this process, the hydrogen reacts with the sulfur in oil shale to form H_2S. It is economically desirable to reduce the consumption of hydrogen. One of the ways this can be achieved is by removal of the sulfur compounds from the oil shale before it is retorted.

Because of the promising results obtained in the microbial desulfurization of coal, microbial desulfurization of oil shale may be feasible.(6) As part of the research performance for the PFH program, IGT conducted research to examine the ability of the cultures developed for coal desulfurization as well as cultures enriched from oil shale to remove the sulfur from shale. In shake flask experiments, desulfurization of oil shale was demonstrated. Chemical analyses of the sulfur content of the oil shale after 14 days incubation indicated as much as 24% reduction of the sulfur content. No sulfur reduction in abiotic controls suggested that the reduction observed was the result of biological action. Future bench scale studies are planned to optimize the system.

CONCLUSION

These results show that microbial desulfurization systems have the potential for application in clean coal and gas technologies and for the production of clean fuels such as char. Though these systems are developed or under development, they offer challenges that must be overcome before they can have application in a clean technology. In these microbial systems, the rates and efficiencies of removal are often slow to look economically competitive, therefore the rates and efficiencies must be improved. One approach to improving removal rates is through genetic modification of the organism or modification of the coal or oil shale to make them more amenable for targetted microbial reaction. Currently, IGT is utilizing this approach to enhance the coal biodesulfurization capability of IGTS8. With the use of any microbial systems, there is always the challenge of successfully separating the clean product from the cell biomass without any loss of product. One approach that would eliminate the biomass completely is to develop an enzyme system for desulfurization. Also, the microbial systems unlike chemical and physical systems, can be thermally, chemically, and mechanically unstable, creating additional challenges in a clean technology development. Therefore, the physiology, genetics, and biochemistry of the microbial system must be well understood and effectively communicated to engineers and bioengineers for a successful development and scale-up of bioprocesses. With the participation of multidisciplinary teams who focus on various aspects of the technology development, it is conceivable that some of these technologies will be in the field before the turn of this century on early in the next century.

In conclusion, clean technologies can be developed for the production of clean fuels by using microbial systems; however, further research is needed by scientists and engineers to overcome the challenges that exist and to insure that these technologies and products once developed are environmentally attractive and economically viable.

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ENERGY RESOURCE VS. BURIED WASTE: SPENT POTLINER IN A CEMENT KILN

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Aluminum, one of the most important materials in the United States and the world, is produced by reducing aluminum oxide (alumina), a refined bauxite ore, in an electrolytic cell or "pot". An aluminum reduction plant typically has several hundred of these pots, each producing several thousand pounds of aluminum per day.

With a sincere and proven commitment to protecting the environment, aluminum plants are successfully coexisting with their surrounding neighbors. Some immediate neighbors of this particular plant are pine trees and ground vegetation, the protected red cockaded woodpecker, white tail deer, fox squirrels, and, of course, mankind.

As noted earlier, these plants use many pots to meet the world's demand for aluminum. The lower half of the pot is a rectangular steel shell that is lined with carbon blocks and insulating materials. The carbon lining blocks are made of calcined anthracite coal, using coal tar pitch as a binding agent.

These pots operate continuously, until the pot lining fails and must be rebuilt. This pot "life" is typically three to seven years. The old lining is demolished, dug out, and the carbon and insulating materials are separated so that the components may be collected for recycling. The carbon material is known as spent potliner (SPL). It is estimated that over 100,000 metric tons of SPL is generated annually.

During the operation of the pot, low levels of fluoride and cyanide are formed in the liner. The level of cyanide varies greatly, and predictably, within specific locations of the liner. SPL has a high energy value, 8000 to 9000 BTU/lb, making it a valuable resource as a direct fuel, and a material that should not become a waste.

Years of recycling efforts by the aluminum industry have resulted in several productive and environmentally sound uses for SPL. One of these successful methods is the result of research by the Aluminum Company of America (ALCOA) and the Portland Cement Association. Laboratory tests indicated that SPL could be used as a fuel supplement and mineralizing agent in a cement kiln. In 1983, a one week test was conducted by Alumax of South Carolina and Santee Cement Company, with the successful results leading to a long term evaluation and practice.

The process for producing cement is briefly described and illustrated by the process flow chart, Figure 1. Cement clinker is produced by burning a carefully proportioned and finely ground, raw mix in a rotary kiln. Within the kiln, volatile components are driven off, and partial melting occurs, leading to nodulation of the feed into rounded balls, called "clinker". After cooling, the clinker is ground, with a small amount of gypsum, to the fine powder known as Portland Cement.

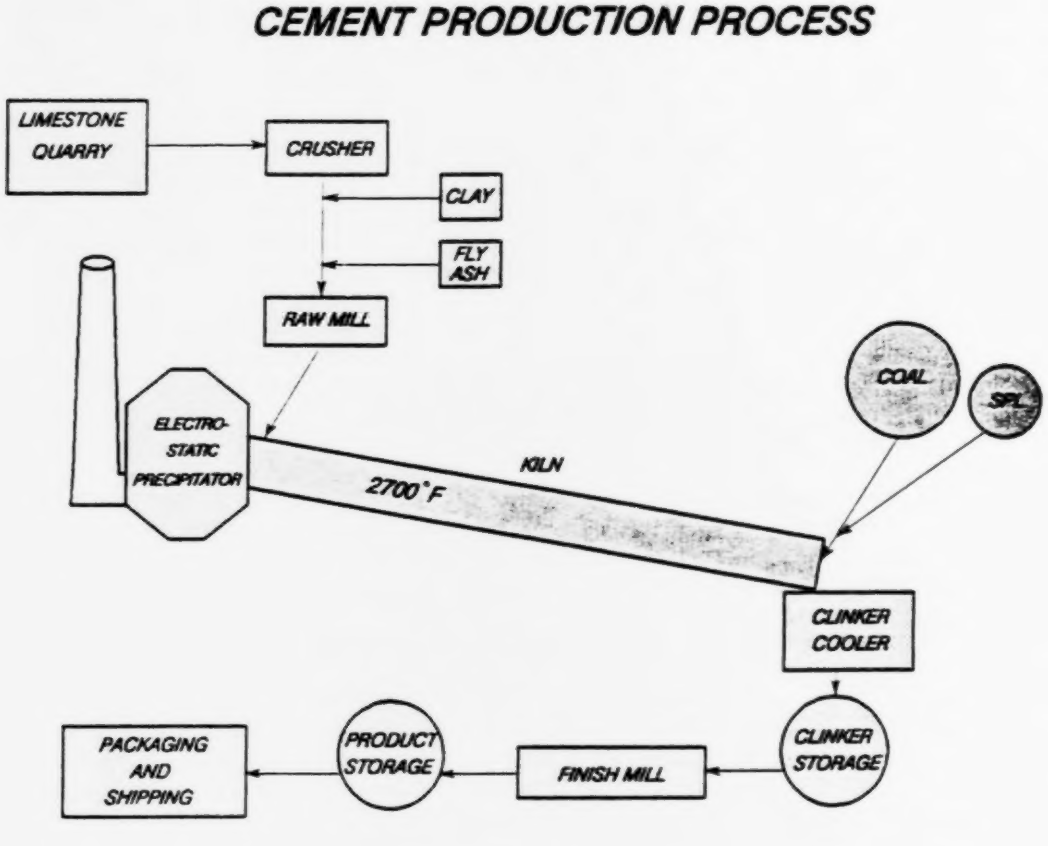
CEMENT PRODUCTION PROCESS

Figure 1. Cement production process.

The high clinkering temperatures, about 2700 degrees F, make it possible to burn almost any fuel once combustion has been initiated. Since most plants burn coal, and since cyanide dissociates at about 1500 degrees F, the replacement of a small fraction (about 2%) of the coal with SPL is a possible and sensible procedure (1).

From 1984 to 1988, over 13,000 tons of SPL were beneficially used as a fuel supplement and mineralizer in South Carolina cement kilns. At the Alumax of South Carolina aluminum reduction plant, the SPL was crushed, stored safely in a large building, and shipped to the cement plant on an as-needed basis. It was then blended with coal for direct firing into the cement kiln, with the following successful results:

1. Reduction of fossil fuel costs was proportional to BTU content, with a net savings of about $100,000 per year.

2. Fluoride emissions from the kiln stacks was negligible. The fluoride present in the SPL was absorbed in the cement clinker and recycling system.

3. Cyanide destruction was complete, stack emissions were at background levels, and no leachable cyanides could be detected in the clinker.

4. Production rates, product chemistry, and product quality were not adversely affected.

5. Land disposal of this material was completely avoided.

The March 13, 1989 listing of SPL as a hazardous waste under Subtitle C of RCRA, in the absence of specific rules encouraging beneficial and environmentally sound reuse of wastes, terminated this waste minimization effort, and forced the unnecessary and undesirable practice of land disposal.

CONCLUSIONS

The reuse of SPL in cement kilns is a proven safe and efficient method of beneficially using both its energy value and its valuable constituents. It has the support of industry, state and federal regulators and other concerned environmentalists. The responsible practices that have been followed should be continued without the undue burden of additional regulatory requirements and unreasonable costs. Prudent efforts such as this, which take advantage of a resource and prevent land disposal, should be encouraged, not dissuaded by inflexible regulatory requirements.

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THE ENLARGED EUROPEAN ENVIRONMENTAL MARKET: IMPEDIMENTS AND OPPORTUNITIES

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The recent transformation of Central and Eastern Europe offers new challenges and opportunities for business, non-governmental organizations (NGOs), multilateral development banks (MDBs), and government agencies who are participating in environmental remediation and reconstruction efforts. The extent of the damage inflicted upon the environment by over forty years of unrestrained and unregulated industrial development is only now coming into focus. The list of designated "environmental disaster areas" grows with each day. In Poland, the major river systems and surrounding areas are fouled by that nation's chemical, metallurgical, and energy industries. Seven of the eight major rivers in Czechoslovakia are dead or dying. East Germany possesses one of the worst air pollution problems of any developed country, due—in large part—to the burning of lignite coal for energy production. Romania and Bulgaria are now just beginning to admit that they even have a pollution problem at all. Across the region, high levels of ground contamination, water and air pollution pose a substantial challenge to Westerners who hope to participate in the economic and environmental revitalization of this region. Likewise, there are significant impediments to increased private and public sector involvement. Each of these impediments—however—provides its own set of opportunities and challenges. In providing the context for this panel, I will touch on just of a few of these.

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* The National Advisory Council for Environmental Policy and Technology (NACEPT) is a free-standing body, consisting of volunteer representatives from business, academia, government, and non-profit organizations and serves to advise and counsel the EPA Administrator on a wide range of cooperative environmental policies and issues. NACEPT is staffed by the EPA's Office of Cooperative Environmental Management which is located in the Office of the Administrator. The International Environment Committee provides a forum for individuals from different—sometimes competing—sectors of the international community to identify international environmental issues, to devise cooperative solutions and strategies for a cleaner national and international environment, to initiate and sponsor projects and programs, and to support international policy and program development.

One of the greatest impediments to increased involvement is the fact that the entire industrial infrastructure of this region is ill-equipped to accommodate sophisticated pollution-control technology or clean technology practices. Whole industries seem impervious to the application of state-of-the-art pollution controls. As a result, some countries—Poland for example—have opted to raze entire factories instead of attempting to retrofit them. While some argue in favor of this approach, it is an expensive and drastic policy—and one, unfortunately, that many of these countries cannot afford to undertake. Reconstruction and rehabilitation efforts in Eastern and Central Europe challenge the West to invent new ways to apply current technology and practices and adapt it to the industrial plant in this region. One of the approaches being considered advocates fitting factories that cannot accommodate the most up-to-date technology, with out-of-date Western technology. Supporters of this approach state that while this plan does not represent an optimal solution, it may be the best and most reasonable option for the short and medium term. Opponents argue strongly for the introduction of totally up-to-date solutions and practices. In any case, while "stop-gap" efforts are applied, increased exchanges of improved technology can provide a long-term systemic solution to the problems of pollution emission controls and the impediment of an inefficient and decaying industrial infrastructure creates increased opportunities for the exchange of technology between the West and this area. As a sidebar to this point, I recently returned from an environmental conference in the Soviet Union where several Soviet speakers voiced fears that the West was planning to dump all of its obsolete technology onto the Soviet

Union market. This is an issue that we must face head on so that these fears do not become realities.

A second major impediment is the lack of comprehensive environmental standards to which newly-built and rehabilitated plants can subscribe and, most significantly, data on which to base these standards. Cooperative multilateral environmental standards must be established by the West and these countries prior to the initiation of large-scale reconstruction activities. One way in which environmental standards can be introduced is through the lending policies of MDBs such as the World Bank and the newly-formed European Bank for Reconstruction and Development (known commonly by its French acronym "BERD"). In demanding comprehensive environmental assessments of industrial undertakings, MDBs can provide an incentive for sound development projects. Furthermore, by bolstering environmental operations and maintenance outlays as an integral portion of loan packages, MDBs can play a positive and aggressive role in determining environmentally sound development strategies. The determination of common environmental standards, however, can only result from cooperation among Western and Eastern European business, NGOs, and most importantly, government agencies. The lack of minimum environmental standards remains a large impediment to the introduction of a comprehensive and successful development strategy for this region. Working in cooperation, MDBs, NGOs, business, and government agencies can play an important role in determining sound development strategies and environmental standards for this region. The experience of the European Community provides an interesting model of "do's, dont's, and maybe's" in this context.

A third impediment is the lack of technical expertise among engineers and managers. Because many engineers and managers were educated and trained merely to fulfill ever-increasing production goals, most of them possess little or no experience in dealing with environmentally-sound production methods and pollution reduction techniques. Currently, an entire generation of engineers and managers must be retrained and re-educated. This situation creates a valuable opportunity to provide technical experts and pollution-control specialists who can re-direct industrial policy to reflect more environmentally-sound methods. Western industry has acquired valuable knowledge in the area of pollution control and efficient, low-impact production methods and is gaining experience in implementing pollution prevention approaches. By supplying Central and Eastern Europe with qualified and experienced experts, the West can transfer its own experience and prevent Eastern and Central Europe from repeating the West's costly mistakes in its program for industrial development.

Finally, the most serious impediment to Western action in Central and Eastern Europe is the lack of experience (on the part of the politicians, managers, and businessmen) with the free market mechanism. The lack of convertible currencies, the stress on mega-projects, the heavy geographic concentration of industry, and the compartmentalization of the economic decision-making apparatus present formidable barriers to outside actors. Successful involvement will be contingent on decentralization and reconstruction of the prevailing economic mindset. For the past forty years, the economic maxim that "bigger is better" has held sway in the formulation of all industrial policies. As reconstruction efforts are undertaken, this maxim must be abandoned. *Massive, inefficient industrial projects must not be supplanted by equally inefficient and massive environmental rehabilitation projects.* There is a temptation among Central and Eastern European economic managers to support mega-environmental projects even though the market may dictate that smaller projects would provide a greater environmental and economic return. Intelligent and efficient environmental remediation efforts will depend upon Western advice and know-how. Western businesses and NGOs have accumulated a wealth of experience in and knowledge of the market mechanism—each could provide valuable instruction and leadership in this area.

The lack of a market mechanism also will impede immediate Western involvement in remediation and reconstruction efforts. Even though most East European countries advocate a return to the market system, it will be several years before it can be adequately established throughout the region. In the meantime, these nations are faced with an unenviable dilemma. Each country needs Western funds and expertise in order to make the transition to a market economy, yet Western funds and expertise will not be readily forthcoming until this transition is completed. Business, NGOs, government agencies, and most important, MDBs can play crucial role in providing funds and expertise so that the transition time can be short and less painful. Public and private sector cooperation can provide a foundation for the implementation of an effective environmental strategy.

Despite the impediments of an inefficient industrial infrastructure, lack of common environmental standards, a dearth of technical expertise, and the absence of a market mechanism, the opportunities for business, NGOs and government agencies in participating in the economic and environmental renaissance of Central and Eastern Europe loom large. A successful development strategy for this region will depend on cooperative action on the part of the public and (emerging) private sector. The speakers this morning will elaborate on the nature of this cooperation, and the impediments and opportunities presented by the enlarged European Environmental Market.

International Conference on Pollution Prevention:
Clean Technologies and Clean Products

Session 37: Hazardous Waste Minimization in DoD Operations
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U.S. AIR FORCE HAZARDOUS MATERIALS MANAGEMENT INITIATIVES

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ABSTRACT

The Hazardous Materials Integrated Management Program (HAZMAT IMP) is an U.S. Air Force initiative to prevent pollution throughout the life of a weapon system, from concept to disposal. The major elements of this program focus on the hidden costs associated with hazardous materials when acquiring new systems and supporting existing systems. On-going process and systems research by the Logistics, Supply and Maintenance community will improve inventory control, remove requirements and provide substitutes for hazardous materials. Costs related to the safe handling, storage and disposal of hazardous materials must be considered as part of the total lifetime system costs. The HAZMAT IMP is a comprehensive program to identify, track and replace hazardous materials.

Long-term success will depend on designing the non-use of hazardous materials into the weapons system as a part of supportability. In 1989, Air Force Systems Command requested an unbiased, independent contractor, the MITRE Corporation, to conduct a preliminary study of the existing weapon system acquisition process within AFSC and to recommend initial tasks to reduce the use and generation of hazardous materials. Weapon system design, development, operation and maintenance occurs within the context of a system acquisition process. This acquisition process lays out an orderly strategy for these activities; however, the process must be tailored to each weapon system acquisition.

The MITRE report defined a series of issues that will improve the efficacy of managing hazardous materials during system acquisition.

disposal practices and problems that result from the material processes.

It is clear that we need to change the way we do our business. We need to look at our material selections in terms of performance characteristics and the processes and disposal requirements that each material selection drives.

For example, by selecting the aircraft skin as aluminum, you have automatically determined the maintenance procedures and the ultimate disposal problems. What we are attempting to do is to directly tie the material section to the maintenance processes and disposal requirements. Additionally, we hope to identify the "hidden" costs for personnel protection equipment, special training, medical examinations and differential pay for AF civilian employees. When we have evaluated all the alternatives in the same fashion, then we can make meaningful tradeoffs.

Briefly, I would like to discuss the weapon system acquisition process mandated by law. The top schematic shows the way we do business. Although some steps can be combined for a given item. the overall process is a stepped and orderly approach. Before entering the next phase, there are multiple reviews to validate the need, the approach and the design. For a major weapon system, like a new aircraft, the overall process can take 8-10 years.

Throughout the classical acquisition process, we have different organizations that have responsibility for the program development. The "planning shop" works with the using command to get their ideas down right. Once the concept has been approved, the System Program Office (SPO) has the responsibility to move the product from the paper studies, through design, into production and finally resulting in a fully operational "fielded" weapon system meeting or exceeding the user's original needs.

The SPO can be very large for major weapon systems with several technical experts assigned to one discipline. Smaller SPO's use matrixed technical support to cover their technical requirements. The various disciplines listed are only some of the technical areas required for most weapon systems.

Finally, the systems engineering design approach can be applied to the AF Weapon System Acquisition process. We begin with system level engineering and work down to the detail level, then correct and modify accordingly.

How HM fits into the acquisition process is not new. The AF Scientific Advisory Board (SAB) studied this specific issue on how we select and use this in the "business" process. Their report concluded that we can significantly reduce our outyear HM/HW problem by better identification and selection of materials in the design phase.

The SAB report concluded that the current acquisition process does not even address HM issues and that even if it did, the SPO's are not "technically capable" in this extremely technical area to make a proper assessment of tradeoffs. Even if we could do an adequate job of making selection tradeoffs, we have no way to grade ourselves on how well we have done.

Our job is clear. To make hazardous material management (HMM) a consideration of the SPO and to provide the SPO with the technical support to make sound material selection decisions.

Last fall, we contracted the MITRE Corporation to perform a preliminary evaluation of both our current HM business practices and identify the technical, regulatory and emerging issues that will directly impact how we will do business in the future.

The following summarizes the current practice of HMM. The good news is that the issues are being addressed, albeit not in any technical detail, by the system safety program.

Interviews with our various product divisions pointed out the bad news. First, there is no consistent approach to HMM from SPO to SPO. Next, that there is no formal mechanism to transfer information either from or within the SPO or from the SPO to technical support laboratories, the "experts" in a particular field. We found that HMM issues generally needed a "trained" professional to know the real issues facing the weapon system design. There was definitely a lack of consideration of the total costs devoted to HM issues, in fact most people interviewed had never thought of the maintenance and disposal costs that their decisions were driving. Finally. there was an overall limited consideration of HM issues. Most people accepted the "off the shelf" approach to material selection instead of looking at each design decision as an opportunity to reduce or eliminate hazardous materials or hazardous wastes.

We are clearly not addressing the acquisition issue!

How are we preparing to solve this problem? We want to design out the problem if at all possible. In those instances where we can't design away the issues, and there will be many instances where we cannot, we want to be able to let the field units know what they're getting in terms of maintenance support and disposal requirements.

Our approach will be to give the SPO's the tools and expert technical support they need to make sound decisions. We must also integrate our special HM/HW needs into the federal acquisition process and to advocate these needs to our biggest supporter, industry. Our impact is simply to standardize the way we think about HM/HW issues and enable a proper technical tradeoff to occur.

To make this program effective, we must address five key issues. First, we must tailor the existing federal acquisition process to account for the diversity in products produced. The type, number and complexity of HM issues found in the production of hand held radios is completely different than those for a major weapon system, such as the B-2 bomber.

Second, we must get a clear handle on what is a hazardous material. We are constrained by use of hazardous materials listings such as Federal Standard 313 and Department of Defense Directive 4210.15 which defines a hazardous material as:

> "Anything that due to its chemical, physical or biological nature causes safety, public health or environmental concerns that result in an elevated level of effort to manage it."

We need to develop a "working definition" to evaluate the material and the process and not just use laundry lists to perform technical tradeoff evaluations. For example, a smaller volume of a hazardous material in a closed system may be far more acceptable than a large volume of a less hazardous material in an open system. We must begin to look past the obvious questions to properly evaluate HM for the total life cycle of the weapon system.

We also need to be more attuned to emerging regulatory issues as we proceed through the development process. It does us no good to design an aircraft to meet very specific technical specifications and not be able to sand, strip, paint or fly in California.

Early identification of HM issues is the key to flexibility in the design. As you proceed through the phased acquisition process, it costs more and more to make a modification to the weapon system design. It pays to identify our HM/HW concerns early in the process.

Finally, we need to support the SPO personnel with the right balance of technical expertise. This does not mean to assign a full time toxicologist to each SPO. What it does mean is to be able to handle each technical issue arising from the SPO with the right expert. This could result in a complimentary series of design handbooks, computer databases, and consultative support from Air Force and other DOD sources.

From the recommendations of the MITRE preliminary report, we have consolidated and prioritized the follow-on tasks that remain to be accomplished. The first four have been ranked as critical to our program success. First and foremost we must be able to get a tool into the hands of the decision makers. That tool will depend heavily upon the "working" definition of HM described earlier.

We also believe strongly that our relationship with the contractor must be more refined in the HM arena. We are developing boilerplate contractual language and guidance to the SPO's on how to tailor its use for the particular technical evaluation at hand.

To integrate HM concerns across the entire acquisition process, we need a staged approach for identifying decision points and roadblocks relative to the project timetable. It doesn't matter how good the technical information we have is, if we can't supply it to the right decision maker in a timely manner. The slower we are at identifying roadblocks the less chance we have of having our concerns adequately addressed. I believe the dates reflected for these tasks to be achievable.

The program tasks identified on this slide are not labeled as critical, but they are nevertheless extremely important to the success of this program. A comprehensive training strategy and identification of related industry and academic courses in HM will go a long way in educating the SPO personnel on the type and complexity of HM issues.

To help eliminate the "not invented here" syndrome and to let everyone gain from shared experiences, we will establish a lessons learned repository or tie into the existing Air Force lessons learned Databank.

We feel that the contractor will be the key to this program. As part of our program, we hope to evaluate several current contractor practices in HMM. Not to critique them for their efforts, but to learn from their management and manufacturing techniques and apply those good ideas to our Air Force programs. Tying closely with this program task is to define the criteria and procedures that will be used to evaluate contractor designs as having adequately addressed our HM concerns.

The last four program tasks are more programmatic, but still necessary for program success.

We hope to better determine the support requirements, both technical and non-technical as we work through the roadblocks we encounter.

As part of the technical support, we will need for this program, it is obvious that we will need to tap into multiple databases for toxicological, regulatory and other national and international information sources. The initial phase will be to perform a requirements analysis for such a decision support system.

The final two program tasks are more for our own uses. We need to be able to define and document our wins and losses as we progress through this program. Finally, we need to maximize cooperation between the services and industry by supporting a technical exchange between all the players in HM.

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VIEWGRAPHS

US AIR FORCE

HAZARDOUS MATERIAL MANAGEMENT INITIATIVES

HAZARDOUS MATERIALS INTEGRATED MANAGEMENT PLAN
(HAZMAT IMP)

- Prevent pollution throughout life of weapon system
- Identify "hidden" costs associated with HM
- Improve inventory Control of HM
- Investigate substitutes for HM

A COMPREHENSIVE PROGRAM TO IDENTIFY,
EVALUATE, AND REPLACE HM WHERE POSSIBLE

OVERVIEW

WHAT'S THE PROBLEM?
HOW WILL WE SOLVE IT?
WHAT PROGRAM TASKS REMAIN?

WHAT'S THE PROBLEM?

- MATERIALS
  (COMPOSITE FIBERS, CHEMICALS ..)
- MATERIAL PROCESSES
  (MANUFACTURING, STRIPPING, PLATING ..)
- DISPOSAL
  (PROPER HW DISPOSAL, WASTE STREAM MINIMIZATION ..)
- WAY WE DO BUSINESS
  (IDENTIFY,TRACK, REPLACE HM/HW ..)

MATERIAL SELECTION: ALUMINUM (AIRCRAFT SKIN)

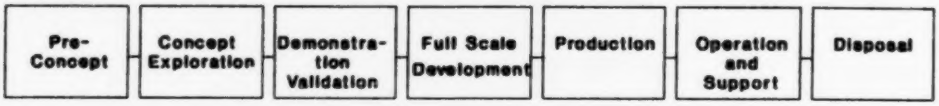
MATERIAL PROCESSES	HIDDEN COSTS
Corrosion treatment - chromic acid	Eye protection, protective clothing.
Priming - epoxy w/chromates	Ventilation, high efficiency respirator, protective clothing.
Painting - polyurethane	Ventilation, air-line respirator, protective clothing.
Stripping - methylene chloride, MEK	Ventilation, respirator eye protection, protective clothing.
Sanding - dust	Eye protection, hearing protection, protective gloves.

DISPOSAL
Chromic acid - toxic & corrosive HW
MEK, methylene chloride - toxic HW

(ALTERNATIVES: FIBERGLASS, COMPOSITES)

WEAPONS SYSTEM ACQUISITION

PHASE:



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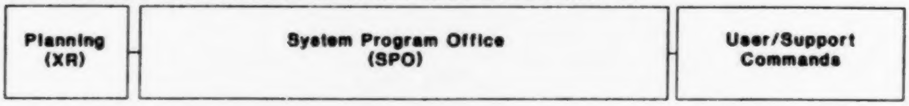
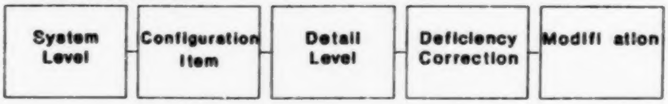
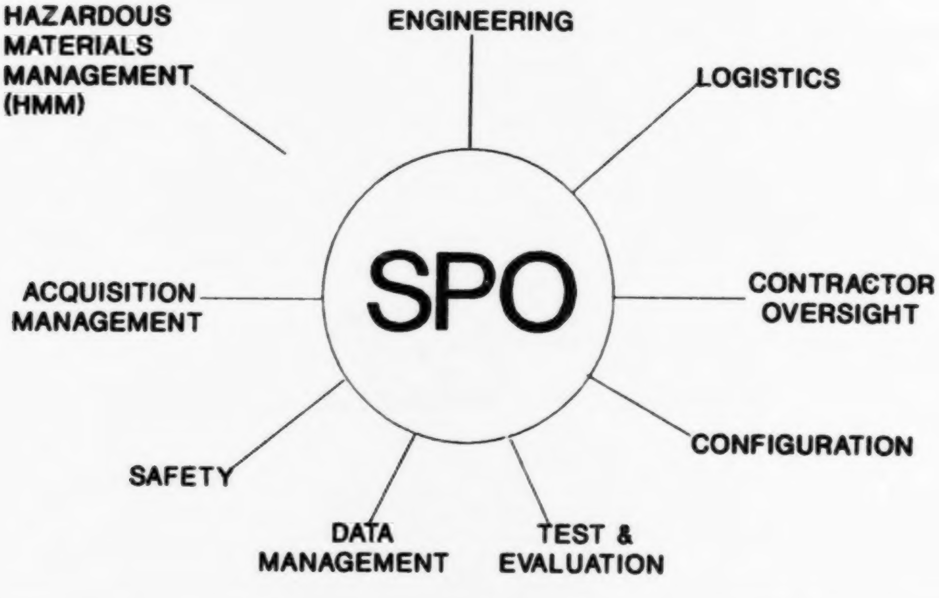


SYSTEMS ENGINEERING:





USAF SCIENTIFIC ADVISORY BOARD (SAB)
OCT 1986

FOUND:

- We can reduce outyear HM/HW problem through early identification and selection of materials

BUT:

- Current acquisition process does not address HM/HW issues
- SPO unable to do technical assessment of HM/HW issues
- There are no methods to assess the effects of HM/HW decisions

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SUMMARY OF OUR CURRENT PRACTICE

- Hazardous material management (HMM) concerns are not addressed within the system safety program
- Product division interviews showed:
    - No consistent approach to HMM
    - No formal mechanism for info transfer
    - A general lack of HMM expertise at the SPO
    - No clear consideration of total HM cost
    - Limited consideration of HM

WE ARE NOT ADDRESSING THE ACQUISITION ISSUE

HOW WILL WE SOLVE IT?

- GOAL - We want to design problem out or pass on lessons learned early
- APPROACH
    - Provide SPOs with tools needed for sound decision-making
    - Integrate HM/HW into acquisition process
    - Advocate HM/HW issues to industry
- IMPACT
    - Standardize HM/HW decision-making
    - Enable technical assessment of HM/HW concerns

ISSUES TO BE ADDRESSED

- Systematic approach - accounting for diversity
- Working definition of hazardous materials - various approaches
- Regulatory awareness - existing regulations and emerging issues
- Early hazardous materials identification - flexibility versus uncertainty
- Expertise - where and how much

DODD 4210.15, HAZARDOUS MATERIALS POLLUTION PREVENTION

"Anything that due to its chemical, physical, or biological nature causes safety, public health, or environmental concerns that result in an elevated level of effort to manage it"

WHAT PROGRAM TASKS REMAIN?

CRITICAL

- Identify cost drivers and develop LCC model (Fall 91)
- Develop "working" definition of hazardous materials (Spring 91)
- Develop HM contractor language and guidance on its use (Fall 91)
- Define staged process for HM identification relative to acquisition timetable (Summer 91)

WHAT PROGRAM TASKS REMAIN?

- Develop a training strategy and selected course materials for program personnel
- Establish lessons learned repository
- Evaluate current contractor practices in HMM
- Define criteria and procedures for monitoring contractor efforts under AMHM
- Determine support requirements
- Perform requirements analysis for decision support system
- Define measure of success in AMHM
- Institute technical information exchange

END

ILLINOIS/EPA WRITE PROGRAM

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ABSTRACT

The State of Illinois, through the Hazardous Waste Research and Information Center (HWRIC) and the University of Illinois, is participating in U.S. EPA's three-year Waste Reduction Innovative Technology Evaluation (WRITE) Program. This program is designed to encourage the interaction of government and industry to demonstrate and evaluate at least five innovative production and recycling options for reducing waste generation. The scope of the evaluations includes determining the engineering effectiveness of the technology, measuring the reduction in waste volume and degree of toxic hazard to all media, and assessing economic return or payback. A major objective is to establish reliable performance and cost information for pollution prevention technologies and techniques.

HWRIC has taken a four pronged approach to identifying and selecting industrial participants; distribution of announcements at meetings, promotion of the Program with companies requesting technical assistance with their waste management problems, contacting equipment vendors, trade associations, and Governor's Pollution Prevention Award winners that HWRIC dealt with in the past, and soliciting proposals for appropriate projects with matching funding available from HWRIC. Fourteen most promising projects were identified out of over 50 industrial contacts. These were assessed using a worth assessment model and five were selected for evaluation under this Program.

The five projects include two with printers, two with electroplaters, and one with the American Foundryman's Society. The printing projects involve evaluation of water-based inks in flexographic printing and soy oil-based inks in offset printing.

The electroplating projects involve recovery and reuse of alkaline zinc where zinc cyanide was previously used and the use of a batch vacuum evaporative system to recover and reuse chemicals and water in several plating lines.

The approach used in this Program has been successful to identify industrial participants. All aspects of the approach have been useful and necessary. Some companies have been reluctant to participate because of concern over proprietary information about their process, unwillingness to share the results with their competitors, and general reservations about working with state government. Other obstacles have included technologies that are beyond the scope of the Program, matching the participants timing with that of the Program, and obtaining the information needed from the participants on their materials and processes to perform the evaluations. These problems can be overcome if all Program participants are committed, the expertise and resources needed to undertake the evaluations is available, and the participants are flexible.

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication.

INTRODUCTION

In June of 1989 the U. S. Environmental Protection Agency (EPA), Office of Research and Development began a three-year cooperative agreement with the Hazardous Waste Research and Information Center (HWRIC) and the Institute for Environmental Studies (IES) of the University of Illinois (U of I) as a part of EPA's Waste Reduction Innovative Technology Evaluation (WRITE) Program. HWRIC is a unit of the nonregulatory Illinois Department of Energy and Natural Resources and is affiliated with the University of Illinois.

The WRITE Program is designed to encourage the interaction of government and industry to demonstrate and evaluate innovative production and recycling options for reducing waste generation. The approach of federal and state cooperative efforts to incorporate pollution prevention technologies and practices in industrial operations is also being developed under this Program.

Engineering and economic evaluations of at least five waste reduction technologies within the State will be conducted under this cooperative agreement. An additional aspect of the Illinois Program is to develop a "Degree of Toxic Hazard" evaluation technique which will be used in the evaluation of each of the technologies.

In this paper, the approach used to identify technologies and industrial participants is summarized. Each of the selected technologies to be evaluated is then described. This is followed by a discussion of the results and plans for completion of the project.

PROJECT OVERVIEW

For each technology to be evaluated a ten step approach is being taken. The ten steps are:

1) select the project and obtain company commitment,
2) determine the project requirements,
3) prepare a draft quality assurance project plan (QAPP),
4) revise the QAPP per review comments,
5) conduct field test preparations,
6) collect in-plant measurements and economic data,
7) evaluate and analyze the test data,
8) prepare draft project report,
9) conduct report review, and
10) prepare and publish final project report.

During the first year the major activities have been to identify candidate technologies, contact potential cooperating industries and technology developers, assess and select technologies for in-plant evaluation, and develop the Degree of Toxic Hazard evaluation system. Steps 2 through 4 have been undertaken for some of the projects. Technology evaluations (steps 5 through 7) are scheduled to be undertaken during the second year of this Program. Final project reports and an overall Program report will be prepared during the third year.

Since the start of the project, more than 50 industries, companies, trade associations and consultants have been contacted regarding their willingness to participate in the program. To make these contacts and identify potential industrial participants, four coordinated approaches were used.

The first approach was to prepare announcements for distribution at various speaking engagements given by project staff. Presentations have been made to industry on over twenty occasions. For those companies that expressed interest informational material was provided and site visits were arranged.

Second, companies contacting HWRIC for technical assistance on their waste problems were also approached when their needs were suitable. HWRIC personnel described the WRITE Program and arranged for meetings to explore their interest. Meetings have been held with personnel from more than 25 companies regarding their participation in the project.

The third approach used was to make contacts with various companies and trade associations that project personnel had dealt with in the past. These included companies who had applied in previous years for the Illinois Governor's Pollution Prevention Award. Two candidate companies were identified in this way.

The fourth approach used was to invite companies to submit proposals for state funding of waste reduction projects. For the past three years HWRIC has funded waste reduction projects with industry with an objective similar to the WRITE Program. This approach was designed to use state funding to help attract industry to participate in this Program. Projects currently funded and new proposals were considered. Three of the participating companies plus two other appropriate companies were identified by this approach.

TECHNOLOGY SELECTION APPROACH

Through these approaches, fourteen potential WRITE projects were initially identified. A worth assessment model evaluation was undertaken to evaluate and rank each of the fourteen potential waste reduction projects according to 12 technical criteria. The selection criteria used for choosing the waste reduction technologies were:

1) Type of waste-minimization technology (source reduction or recycling applications),
2) Status of development or level of maturity according to a maturity index (chosen technologies developed beyond the proof-of-concept stage to at least the pilot plant scale),
3) Unique nature of the technology (not previously evaluated for waste reduction effectiveness),
4) Applications for reducing priority wastes or for more than one process primarily in small- and medium-scale operations,
5) Source-reduction-performance capability or the extent of waste volume or toxicity reduction expected,
6) Extent of process modification,
7) Cost-effectiveness of the technology,
8) Process safety and health considerations,
9) Cost to the EPA and U of I (HWRIC and IES),
10) Demonstrator's qualifications,
11) Legal/contractual issues, and
12) Length of the project.

A worth assessment model was the decision tool used. With this model each of the selection criteria are given a weighted score. The ratings are added to obtain an overall rating. The results of this evaluation for the five selected technologies are summarized in Table 1. Each technology involves source reduction or recycling, is within the prescribed maturity index limits, and is unique in that it has not previously been evaluated for its cost and waste reduction effectiveness. Also, it has been determined in discussions with each company that no major legal or contractual issues are pending for these projects.

After this review, five technology evaluation projects were selected for this Program. The selected projects and industrial participants are:

1) Flexographic printing with water-based inks and alternative cleaners (MPI Label Systems in University Park, IL.),
2) Offset printing with soy oil-based inks and alternative cleaners (University of Illinois, Office of Printing Services in Urbana/Champaign),

3) Non-cyanide zinc plating and reuse of recovered chemicals in electroplating (P and H Plating in Chicago),
4) Vacuum evaporative batch recovery and reuse of chromium, copper, nickel, cadmium, brass, and zinc in electroplating (Graham Plating in Arlington Heights), and
5) Recovery and reuse of waste zircon molding sand in the investment casting (foundry) industry (American Foundryman's Society in Des Plaines).

In addition to these five projects, two other projects were identified that may be undertaken if funding and time permit. These alternate projects are evaluation of citrus based cleaners for metal parts degreasing (Lockformer Corp., Chicago) and pickle-liquor recovery and reuse in electroplating (Ionsep Corp., Chicago).

The other main task has been to develop the degree of toxic hazard reduction evaluation system to be used for this program. For each waste stream to be evaluated an equivalent toxic concentration (Ceq) is calculated as follows:

Ceq = A SUM (Ci/BiTi)   where:

A is a constant equal to 300 which is used to allow percent values to be used for Ci and to adjust the results so that a reference material (100% copper sulfate which has an oral toxicity of 300 mg/kg), achieves an equivalent toxicity of 100;
SUM is the sum of the results of the calculation in parenthesis for each component of the wastestream;
Ci is the concentration of component i as a percent of the waste by weight;
Bi is a conversion factor used to convert toxicities (Ti) to equivalent oral toxicities according to (Plewa, et al., 1989); and
Ti is the measure of the toxicity of component i.

The equivalent toxic concentration is converted to a toxic amount, M, by the following formula:

M = S Ceq   where;

S is the maximum size of the waste stream in kg/month.

With these calculations a value for the toxic amount, M, for each waste stream is obtained. This toxic amount accounts for the toxicity and amount of each component in each waste evaluated. The number obtained for M can range from 0 to more than 10,000. This toxic amount can be considered as a relative toxicity rating for each type of waste. For the Illinois/EPA WRITE Program a toxic amount will be calculated for each waste produced before and after the waste reduction technologies are implemented. In this way the change in the relative toxicity of the wastes produced can be evaluated along with measured changes in waste volume.

During the first year of this Program the software computational system has been restructured to make it more efficient and the toxicity database has been expanded for chemicals that are expected to be found in the waste streams. A necessary task has been to obtain information on the chemical make-up of each of the waste streams to be evaluated. This information has been difficult to obtain for some of the commercial products used by the participating companies. In most cases chemical analysis of the wastes will be undertaken to determine constituents and their concentrations for the degree of toxic hazard evaluations.

The first year of this project has been successful in that at least five candidate projects have been selected and all maintaining the project schedules. Considerable effort has been required to identify potential participants, to evaluate each candidate technology, and to select those most beneficial. State funding has been used to assist with three of the projects and cooperative agreements have been reached with the other two. One draft QA Project Plan was reviewed by EPA and is being revised. Two other QA Project Plans are being prepared by Program staff. Preliminary results have been obtained from three of the projects.

ENGINEERING AND ECONOMIC EVALUATIONS

It is anticipated that each evaluation will be completed during the second year of this Program. This evaluation involves an in-depth study of the process, a literature review, material and energy balance computations, a field demonstration, and cost estimation. The short time involved in conducting the evaluation of a technology precludes examination of long-term operating data for evaluation of life-cycle costs and long-term operating problems. The scope of the project also limits the extent of the evaluation.

Once a technology or technique has been selected for demonstration, a site specific Quality Assurance Project Plan will be prepared. This plan will address sampling locations, types of analysis to be performed, data handling procedures, etc. specific to a given technology evaluation. Although the content of each plan will vary depending on the technology studied and the extent of the engineering and analytical evaluation, the following items will be common to each QA Project Plan:

1) Testing program duration and schedule,
2) Development of detailed evaluation design,
3) Sampling and analytical procedures, and
4) Health and safety concerns.

PROJECT DESCRIPTIONS

Descriptions of the activities to be undertaken for each of the five selected project are provided below. Included in the description of each project is the technology or technique to be evaluated.

I. MPI Label Systems - flexographic printing with water-based inks and alternative cleaners.

MPI Label Systems of University Park, IL is a small label-printing firm which uses narrow-web, multi-color flexographic presses. A recent management decision mandates that they use materials that are least toxic to individuals and are not hazardous to the environment. As a result they converted to the exclusive use of water-based inks and are evaluating the use of alkaline and citrus-based cleaners. Prior to the change, their inks and cleaners were compounded with alcohol solvents.

The water-based inks contain only about 5% alcohol. A full line of 720 different colors are available with the new inks and their print quality is at least equal to their predecessors. Disposal of small quantities from clean-up into the sanitary sewer is acceptable to most treatment plants. Larger quantities are filtered to remove the organic pigments. The latter material is then sent to a landfill.

The citrus-extract cleaning agent appears to perform satisfactorily. The other new cleaning agent is composed of non-halogenated organic compounds which remove spills of plastic label coating. Factors being evaluated include product quality, waste minimization, employee tolerance and economic analyses.

At least three meetings have been held with MPI Label Systems plant staff and WRITE Program staff to establish the scope of the evaluation to be undertaken and for project staff to gain familiarity with MPI's operation.

II. U of I, Office of Printing Services - offset printing with soy-oil based inks and alternative cleaners.

The Office of Printing Services (OPS), University of Illinois at Urbana-Champaign, is participating to cooperatively evaluate the change from petroleum-based inks to soy oil-based inks in offset printing operations. The change is being considered because soy oil is a renewable resource, less air emissions may result, any ink wastes may be more degradable, and the end products may be more easily recycled.

A cooperative agreement was signed with OPS for this project. During this project, data will be collected on the volume of inks used, the effectiveness of various press clean-up chemicals, the amount of waste produced, and the comparable costs of using both types of inks. Any change in toxicity of wastes produced by the alternative inks and cleaners will also be determined.

The Office of Printing Services will evaluate the use of soy oil inks and appraise any effects on printing quality. OPS will also provide all necessary information on volume of materials used, effectiveness of alternative cleaners, material costs, waste volumes, etc., required to make engineering and economic evaluations of the soy oil inks.

III. P & H Plating - non-cyanide zinc plating and reuse of recovered chemicals in electroplating.

P & H Plating Company is a large Chicago electroplating job shop. Their main plating lines include cadmium, chromium, copper, nickel and zinc. Of the zinc processes, there are five plating lines -- three rack lines and two barrel lines. All the zinc lines use zinc cyanide to plate mostly steel parts. In the U.S. plating industry, 85% of zinc plating is done with cyanide baths because of the ease of maintenance, lustrous and ductile deposits, and easy preplate cleaning requirements.

For the current project, P & H Plating is changing one of the zinc barrel lines to non-cyanide alkaline zinc chemistry. This particular line has a 2500 gallon plating tank divided into nine plating stations. The cyanide plating bath will be replaced by the non-cyanide alkaline zinc bath, the main component of which is zinc hydroxide.

The most innovative aspect of this project will be the recovery of zinc hydroxide from the rinse water for reuse in the plating bath. Rinse water containing low concentrations of plating solution will be treated by pH adjustment to precipitate the zinc hydroxide. This will be filtered, monitored as to suitability for reuse, and its chemistry adjusted as needed before being returned to the plating bath. The filtrate will be recirculated and reused as rinse water. Some dilution with fresh water may be necessary.

Under the WRITE project the capital cost of the changeover, reduction in sludge volume and toxicity waste, reduction in volume of cyanide bearing waste water, reduction in rinse water use, reduction in operating costs, and plating quality before and after the change will be evaluated. This project is being undertaken cooperatively with a consultant, the Center for Neighborhood Technology (CNT), with State funding from HWRIC. CNT has collected some samples of the zinc plating line prior to installation of the new equipment. Since then the new equipment for recovery and reuse of the zinc hydroxide has been installed. Evaluation of this equipment and the technology change is scheduled for July and August.

IV. Graham Plating - vacuum evaporative batch recovery of chromium, copper, nickel, cadmium, brass and zinc in electroplating.

Graham Plating Company is a medium-size plating job shop. Their major plating lines are chromium, copper, nickel, cadmium, brass and zinc. The company recently moved to a new facility in Arlington Heights, northwest of Chicago. The new plant is designed to be a zero-discharge facility producing no waste water or sludge. It is the company's goal to recover and reuse all plating chemicals. The main waste reduction feature of the new plant will be a Vacuum Evaporative System (VES). Rinse waters containing low concentrations of plating solutions from each line will be collected in separate storage tanks and fed to the VES and reused for rinsing and other operations. The concentrate containing plating chemicals from that VES will be monitored as to suitability for reuse in the plating bath, its chemistry will be readjusted, if needed, and pumped back to the plating tank for reuse. The entire system will be automated.

V. American Foundryman's Society - recovery and reuse of waste zircon molding sand in the investment casting (foundry) industry.

State funding has also been given to the American Foundrymen's Society (AFS), headquartered in Des Plaines, IL, to develop a solution to one of the investment casting industry's waste management problems. Zircon silicate, which is a strategic and costly sand, is one of the aggregates utilized in the high quality investment casting process to form a mold. Currently there is no way to reuse the zircon constituent of the spent mold materials; it is discarded and sent to a landfill. Sometimes the sand contains significant quantities of metal contaminants.

Investment casting in the U.S. is a $3 billion industry. There are 14 foundries in Illinois employing approximately 1,400 people. From these foundries over 5,000 tons of mold material is disposed of each year at an approximate cost of $175,000. Typical tipping fees are $15-20/ton with transportation costs at least equal to the tipping fees.

The goal of this project is to develop a practical and economical approach to reclaiming and reusing the used zircon sand. Currently, AFS is evaluating candidate technologies for recovery of the sand. By the end of the summer of 1990 the most promising technology will be selected and the project requirements determined. Mechanical and thermal reclamation techniques will be investigated. Potential uses of the reclaimed zircon include reuse in the foundry, production of zirconium and production of base ceramic products for other industries. Pilot scale testing of the reclamation and reuse process which is developed will be performed in six Illinois investment foundries. The project is expected to result in an economical use for what is currently a waste, will save valuable landfill space, and money for the foundry.

DISCUSSION

The four pronged approach used to identify industrial project participants and appropriate technologies has proven successful. It is helpful that HWRIC and the University of Illinois are not regulatory agencies. The experience that HWRIC has had in the past five years of working with companies has also been a benefit. For some participants the availability of state funding to cover a portion of the cost of the project was necessary for them to undertake the project and to share the results. Since HWRIC had sponsored the Governor's Pollution

Prevention awards for the past four years, this positive recognition was an inducement for other companies to consider participation.

Barriers to this Program include the need that most companies have to protect proprietary information on their processes and equipment. In most cases an evaluation can be performed without using that information but in some cases this issue is insurmountable. The past experience some companies have had working with government agencies has a strong influence on their willingness to participate. Small to medium-sized companies are generally more interested in obtaining assistance with these types of projects. Large companies have the necessary resources and staff to undertake these projects. The main interest of large companies, as stated by several approached by HWRIC, is often to be given favorable publicity about what they are doing to reduce their wastes and be good corporate citizens.

The scope of the evaluations undertaken on this Program is generally limited to a month or less of in-plant sample collection of a few key parameters. There usually is not enough time to evaluate the technologies under all operating conditions over a long period of time. Some industrial waste reduction projects are on a very tight time schedule that leaves little time for collection of samples before the new technology is installed. It is often necessary to adjust the project schedule or scope to fit within the production schedules and business plans of the industries. Considerable difficulties have also been encountered in obtaining adequate information about the materials used and the costs that a company has for production and waste management.

With persistence and by contacting enough prospective participants, enough willing companies can be found to undertake these cooperative technology evaluations. Expertise and familiarity is needed about the industrial processes and waste reduction technologies being evaluated so that an adequate evaluation plan can be devised. This requires close coordination between the evaluation team and the industry. The results of these evaluations are of great interest to many other companies and this is a worthwhile approach to evaluating waste reduction technologies.

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Table 1. WORTH ASSESSMENT MODEL EVALUATION - ILLINOIS/EPA WRITE PROJECTS

Criteria	Weight	Score - Rating				
		MPI	AFS	P & H	Grahm	UI/OPS
Status of Development	5	2.5	0	0.5	2.5	2.5
Applications	20	13	10.6	13	13	13
Priority Waste		3	0.6	6	6	3
Range of other applications		4	4	4	4	4
Size of Industry		6	6	6	6	6
Source Reduction Performance	20	20	10	20	20	10
Extent of Process/Equip. Modifications	10	10	5	5	1	10
Cost-Effectiveness of Technology	15	7.5	7.5	15	15	7.5
Safety & Health Considerations	5	5	2.5	5	5	5
Cost to EPA & local governments	5	2.5	2.5	2.5	2.5	2.5
Demonstrator's Qualifications	10	10	10	10	10	10
Legal/Contractual Issues	5	5	5	5	5	5
Length of Evaluation	5	5	0.5	5	0.5	5
TOTALS	100	65.5	43.6	61	63.5	50.5

MPI = MPI Label Systems, Inc.
AFS = American Foundrymen's Association
P&H = P & H Plating, Inc.
Grahm = Graham Plating Works
UI/OPS = University of Illinois/Office of Printing Services

POLLUTION PREVENTION IN THE ELECTRIC UTILITY INDUSTRY

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ABSTRACT

INTRODUCTION
The electric utility industry generates several types of waste by-products as a result of electricity production. These by-products vary in composition, frequency of generation, and quantity. Management practices include landfills, ponds, incineration or evaporation, reuse/recycle and source reduction. Examples of waste by-products include coal ash, FGD system by-product, metal cleaning wastes, solvents, runoff from coal piles and various blowdown streams.

METHODS
The Electric Power Research Institute (EPRI) and individual utilities have been involved in a number of activities aimed at cost-effective by-product management. Studies have included construction of highways using coal ash, substituting coal ash for cement and aggregate in concrete and testing uses for waste streams such as boiler chemical cleaning wastes. Further, several guideline manuals on options for waste management have been prepared for such wastes as antifreeze, asbestos, petroleum contaminated soils, batteries and various wastewaters.

RESULTS
These studies have shown that, in general, electric utility wastes are non-toxic and non-hazardous. Several management options currently exist for many wastes; however the actual costs and applicability are dependent on the regulatory and environmental climate where the waste is generated. In some cases, the options available are quite limited and thus management costs could be relatively high. Research by EPRI, the federal government and private industry is rapidly expanding the management options available. Databases have been established to track emerging technologies and currently available techniques (including waste minimization opportunities) are documented in published reports.

CONCLUSIONS
The activities described in the paper are multi-media in perspective. The electric utility industry's continuing goal is to design and operate power plants in a manner which poses minimal environmental risk while at the same time taking an integrated and innovative perspective to waste management.

POLLUTION PREVENTION IN THE ELECTRIC UTILITY INDUSTRY

INTRODUCTION

The electric utility industry produces many and varied by-products in the process of generating and distributing electricity and in servicing its customers. These by-products span a wide range in terms of volume and rate of generation, chemical and physical form (solids, liquids, gases), and management methods. In general, the industry does not use or dispose of many by-products which carry a toxic or hazardous designation under RCRA (characteristic or listed), the Clean Water Act, Clean Air Act or other Federal or individual state laws and regulations. For example, EPA's Report to Congress "Wastes From The Combustion of Coal By Electric Utility Power Plants" recommended that high volume coal combustion residues--fly ash, bottom ash, boiler slag, and flue gas desulfurization(FGD) sludge--not be regulated as "hazardous waste" under Subtitle C of RCRA (1). In fact, the Report encouraged utilization of these combustion by-products in commerce.

By-products from the generation and distribution of electricity and other associated activities will be categorized into three general types for the purposes of this paper. High volume by-products are fly ash, bottom ash, FGD by-product, and boiler slag. Currently the industry produces approximately 90 million tons per year of this material (2). The second category is low volume/noncombustion wastes. This category spans virtually every other liquid and solid by-product stream. Here the volumes can range from ounces to tons per year. Examples include liquid filled fuses, asbestos, solvents, paint sludges, boiler cleaning wastes, various blowdown streams and ash pond discharges.

The final category, gaseous emissions, represents the source of the high volume solid by-products generated by utilities. This situation begins to get at the heart of pollution prevention as a regulatory philosophy. That is, in cleaning the air of particulates and sulfur oxides, the burden is shifted to the land and water environment. As discussed below, the challenge for utilities is to find uses for this by-product material rather than simply transfer chemicals among media.

The electric utility industry has historically relied on landfills and ponds as its primary solid and liquid waste management strategy. However, as will be noted in this paper, the industry is increasingly pursuing markets for its by-products through brokers, waste exchanges, recycling/reuse; by generating less material; or by using more environmentally compatible materials. This paper will provide several examples of pollution prevention as applied by the electric utility industry and describe the role of the Electric Power Research Institute and others in furthering that objective.

CASE STUDIES OF UTILITY POLLUTION PREVENTION

The discussions given in the remainder of this paper are not intended to be all inclusive but rather provide a glimpse of how the electric utility industry is being innovative in effectively managing its by-products. The intent is to share experiences so others may learn from our experiences and to adopt effective strategies employed by others. Most of the examples cited are individual case studies and should not necessarily be construed as being widely applied.

HIGH VOLUME BY-PRODUCTS.

As noted above, high volume by-products are generated as a result of the air emissions control system at a power plant--electrostatic precipitators, baghouses or flue gas desulfurization systems. Currently, the industry produces about 90 million tons per year of coal ash and FGD by-product-- enough to fill a football stadium to a height of nine miles. Given projections that coal use in the US may double in the next 10 to 15 years, and the growth anticipated for flue gas desulfurization (FGD) systems because of new Clean Air Act legislation, the challenge to manage this increasingly large volume of material will grow substantially.

Currently, about 20% of electric utility industry high volume by-products are used in commerce. The primary use is fly ash as a substitute for cement in concrete. Figure 1 shows that utilization trends have remained relatively constant over the last several years. Although there are many uses for coal ash given its pozzolanic and, in some cases cementitious properties, most potential markets are relatively small. The examples cited below will focus on some potentially large and innovative markets for coal ash that are relatively new.

Highway Construction

Highway construction represents a major potential market for coal combustion by-products, but use to date has been limited. This is due primarily to the unfamiliarity that state highway departments and contractors have with coal ash in these applications. In addition, state environmental permitting agencies need information on the potential impacts of the ash constituents on groundwater. Finally, the materials that coal ash would replace--cement, sand, soil and aggregate are typically locally available at relatively low cost and the suppliers are structured as vertically integrated industries. Thus, coal combustion by-products have a difficult time in cracking the market unless there is a strong cost advantage.

In the State of Kansas, the Kansas Electric Utilities Research Program (a consortium of Kansas utilities) sponsored a program to use coal ash in the renovation of secondary roads. The concept involved spreading 3 to 4 inches of dry ash on the existing surface. The surface was then pulverized to a depth of 6 to 8 inches. Water was added during the pulverizing process to allow cementitious reactions to occur and the mixture subsequently compacted. A top coat of sealant was applied as the final step. This project used a Type C or cementitious ash which is typical when burning low sulfur western coals. The test sections in Kansas were only two miles in length. However, the success of this project has resulted in repavement of over 400 miles of secondary roads in Oklahoma. It should be applicable almost anywhere in the US, especially in rural areas where Type C coal ash is locally available.

The Electric Power Research Institute (EPRI) and several of its member utilities have sponsored six highway demonstration projects in the US using coal ash in several different applications such as road subbase, base course, embankments and as a high cement replacement in concrete. The projects were structured to show the technical acceptability of ash in these applications as well as examine any short-term effects on groundwater. One utility in Pennsylvania used coal ash and stabilized FGD by-product rather than conventional fill materials in an embankment for an interstate highway. They documented savings of over $600,000 for a 1500 foot highway section where 353,000 tons of coal ash were used. These demonstration projects have served as test cases for highway design and construction manuals using coal ash (3,4).

Aggregate Production

Although the largest use of coal ash is as a substitute for cement in concrete, concrete contains only about 20% cement. Most of the remainder is aggregate and water. Therefore, manufacture of aggregate from coal ash would represent a much larger market in the concrete industry. An example of a recent entry into this market is the Aardalite process. It consists of mixing coal ash, water, lime and additives and passing the resulting mixture through a rotating disc pelletizer which forms pebble type material which can be sized according to the need. A 24 hour steam cure is necessary to produce the final product. A full-scale plant is currently in operation in Florida and uses about 150,000 tons of coal ash a year. A similar facility, referred to as Agg Lite, recently started operation in Virginia. The process uses cement rather than lime to produce the aggregate.

Other Uses of High Volume Coal Combustion By-Products

Electric utility coal combustion by-products have been used in over 50 different applications (5). Examples are listed in Table 1. However, many of these uses have limited market volumes and given the large volume of material produced each year, new markets are always needed. Some new applications currently in the research stage that appear promising are as filler materials for plastics and metals. Not only could these materials be produced more cheaply, the ash would add improved properties to the final product. In aluminum, the ash adds improved machining and sound damping characteristics to the metal, making it a good candidate for engine casings. In plastics, the ash could reduce the need for expensive matrix components such as resins or reduce the amount of elastomers in rubber.

The electric utility industry and EPRI are aggressively pursuing existing markets for coal ash and investigating new opportunities through research. While no national goal for coal ash use has been established by the industry, the American Coal Ash Association and the Edison Electric Institute have been active in promoting coal ash as a by-product and in attempting to remove institutional barriers to its use (6).

LOW VOLUME/NONCOMBUSTION WASTES

The following discussion will illustrate several innovative means by which the electric utility industry is pursuing options for reducing disposal volume for a variety of other waste materials generated as part of electricity production and distribution. The major motivation for these new approaches is cost. Many states have designated a wide variety of waste materials hazardous; thus, costs of landfill have increased substantially and potential long-term liability remains an issue for wastes which require disposal.

Antifreeze (Ethylene Glycol)

Electric utilities have large vehicle fleets for servicing their customer territories. A large EPRI member utility initiated a recycling program for its antifreeze and now saves about $90,000 annually. The spent antifreeze is shipped over 400 miles for redistillation and reconstitution back into antifreeze at a cost of $1.50 per gallon versus replacing it at a cost of $8 per gallon. Further cost savings (not quantified) were realized from avoided disposal.

Boiler Chemical Cleaning Waste

Electric utility boiler tubes must be cleaned periodically to remove iron and copper deposits that form on interior surfaces and impede heat transfer and diminish efficiency. There are five common types of solutions commonly used to clean boiler tubes which are generally acidic in nature (e.g., hydrochloric acid). Utilities typically clean their boiler tubes every 1 to 5 years. The volume of undiluted cleaning waste is usually around 125 gallons per megawatt. When this material is combined with several boiler volumes of rinse water, the total volume can add up to several hundred thousand gallons for a large power plant. Although on an annual basis this represents less than a gallon per minute, in practice the material is generated in a short time and therefore must be handled in large volumes.

Some of these cleaning wastes have exhibited RCRA hazardous waste characteristics because of pH or chromium considerably increasing disposal costs (7). Thus, from a pollution prevention point of view, options that minimize waste production, such as source reduction, substitution or recycling are preferred. The following discussion will illustrate examples of how the electric utility industry is applying such approaches.

One innovative electric utility company has initiated a program which eliminates disposal of the cleaning wastes and provides a useful product to another industry. The utility treats the metal bearing solution with lime to precipitate the metals in solution, primarily copper and iron. The clean liquid is then returned to the municipal wastewater system and the resulting sludge is sent to a copper smelter in Arizona. The smelter recovers the copper value and uses the lime as a flux in the smelting process. The utility has estimated savings of approximately $400,000 per year in avoided treatment and disposal costs.

Other utilities have reduced their frequency of cleaning which is a form of source reduction. Further, careful control of boiler cycle water chemistry can reduce the amount of deposition in boiler tubes and therefore reduce the need for cleaning. Another option that appears promising is reuse of the solution in the flue gas desulfurization system. Lab tests have shown that chemical cleaning waste addition slightly improves SO2 removal and increases limestone utilization.

Asbestos Cages

Asbestos has historically been used by the electric utility industry in three forms: (1) in insulation around equipment, piping and cables, (2) in surfacing materials used during construction of utility facilities, and (3) in a variety of other products such as pump and valve packings, piping and equipment gaskets, floor and ceiling tiles, and brake linings for company vehicles. Because various diseases have been linked to industrial exposure to airborne asbestos, its use, handling and disposal is strictly regulated by the Environmental Protection Agency (EPA) and the Occupational Safety and Health Administration (OSHA).

As long as asbestos containing materials remain in good, non-friable condition, abatement actions such as repair, removal and encapsulation are not required. Once damaged or otherwise rendered friable, however, abatement action is necessary to protect workers from airborne fibers. In areas of high maintenance such as around valves and flanges, several utilities have constructed asbestos cages which can be quickly snapped on and off for easy access. This reduces worker exposure to asbestos and reduces the amount of asbestos that must be disposed.

Petroleum Contaminated Soil Reuse

Petroleum contaminated soils are produced as a result of leaks from above ground and underground storage tanks. The typical means of managing such spills is removal of the contaminated soil and transfer to a secure landfill. One utility has found that rather than send the material to landfill, the soil can be incorporated into asphalt to pave light-duty roads in the vicinity of its facilities. This practice has saved $350 per cubic yard in treatment costs for the contaminated soil or between $270,000 and $385,000 per year assuming paving of one road per year.

Spent Solvent Waste Management

Utilities generate small quantities of spent solvent wastes from routine operations such as parts cleaning, paint stripping and vehicle maintenance. Since solvent wastes are typically classified as hazardous, management practices are costly.

Many utilities have already initiated solvent minimization programs. Typical steps include source reduction (i.e., use less solvent), substitution of less toxic materials and recycling of used materials. Table 2 illustrates examples of frequently applied techniques and some of the issues associated with each (8). In terms of waste reduction, using less solvent is the simplest and often least expensive option. Worker training and good housekeeping have been shown to be effective methods. Limiting availability of solvents at facilities is another way to reduce usage. Several utilities have experimented with a single universal solvent, typically either mineral spirits or TCA (1,1,1-trichloroethane) to replace a wide variety of products.

A variety of non-traditional substitutes are available to replace halogenated organic solvents. Alternatives include sodium carbonate or sodium phosphate solutions, emulsion cleaners such as mineral spirits and organic cleaners such as citrus based D-limonene. Substitutes are generally less toxic, but are generally less effective, especially in electrical contact cleaning. Mechanical cleaning can, in many instances, be substituted for chemical cleaners. Extra "elbow grease" is an effective substitute as is sand or bead blasting. Mechanical cleaning works well for paint stripping but is less satisfactory for degreasing and use on sensitive materials such as wood, plastic or soft metal.

A survey conducted by EPRI indicated that that 46% of respondents employ some type of solvent recycling. Figure 2 shows the comparative costs for several recycling options. In most cases, recycling is less expensive than spent solvent disposal as a hazardous waste.

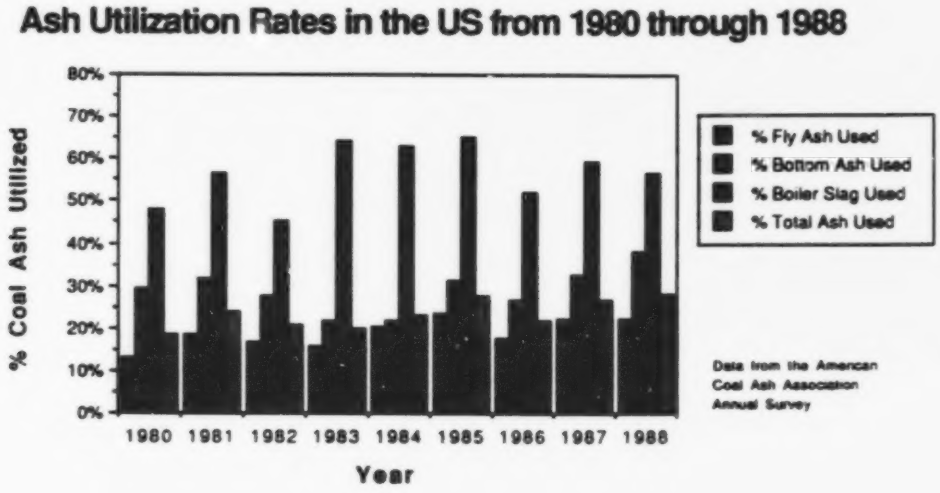
CONCLUSIONS AND FUTURE DIRECTIONS

This paper has provided limited examples of how the electric utility industry is applying the concept of pollution prevention in its operations. Studies have shown that, in general, utility industry by-products are non-hazardous and non-toxic. Nevertheless, landfill costs are increasing and those wastes which are hazardous or toxic and require disposal pose potential long-term liability. Thus, the industry, through EPRI, EEI, ACAA and the Utility Solid Waste Activities Group (USWAG) have together devoted increasing attention to the issue.

EEI and USWAG have focused on improving the legislative and regulatory climate for flexibility in managing utility by-products in an environmentally compatible manner. ACAA has focused primarily on improving markets for the high volume by-products through its efforts with the ash marketers and end-users such as highway departments and contractors.

EPRI research supports the activities of these organizations noted above and its member utility companies through investigating new uses and devising innovative management practices at both laboratory and field scale. Reference manuals have been produced to assist utilities in effectively managing by-products (9,10,11). An emerging technologies database is tracking new developments in more cost-effective by-product management methods. EPRI is also looking into integrated waste management concepts which would examine the entire power generation cycle for opportunities to reuse, recycle or reduce generation of residues, market those residues to others or combine waste management strategies for similar waste materials.

The electric utility industry is supportive of the pollution prevention concept and continues to put new management practices in place that will further this objective. The electric utility industry's continuing goal is to operate its facilities in a manner that poses minimal environmental risk. This drive for new solutions for integrated waste management will involve not only technical innovations, but also institutional and regulatory changes that view pollution control from a multi-media perspective.



Ash Utilization Rates in the US from 1980 through 1988

Data from the American Coal Ash Association Annual Survey

FIGURE 1

TABLE 1

COAL ASH UTILIZATION APPLICATIONS

- •Replacement for Cement in Concrete
- •Raw Material in Brick Manufacture
- •Trench Backfills
- •Area Fills/Landscaping Berms
- •Structural Fill or Embankment
- •Mineral Filler in Asphalt Paving
- •Grouting
- •Pozzolonic Base Course
- •Aggregate in Bituminous Paving
- •Railroad Ballast
- •Mineral Wool Insulation Manufacture
- •Source of Cenoshperes for Insulation
- •Molding Sand Flowability Agent
- •Roofing Granules in Asphalt Shingles
- •Oil Spill Absorbent Material
- •Sewage Sludge Dewatering Absorbent
- •Sanitary Landfill Cover
- •Abandoned Strip Mine Reclamation
- •Water Treatment Filtering Medium
- •Revegetation Aid
- •Aggregate in Lightweight Concrete Block
- •Cement-Stabilized Bases and Subbases
- •Fighting Mine Fires and Controlling Subsidence
- •Cement Replacement in Precast Concrete Manufacture
- •Structural Fills for Housing and Business/Industrial Parks
- •Ingredient in Grouting
- •Flowable Fly Ash Fills
- •Fills for Dams and Dikes
- •Large Fills (e.g., parks)
- •Pozzolonic Base Course
- •Soil Stabilization
- •Aggregate Base Course
- •Cement Stabilized Base
- •Drainage and Backfill
- •Roofing Felt Ingredient
- •Metal Reclamation
- •Wallboard Manufacture
- •Filler Material in Plastics
- •Soil Amelioration
- •Oil Spill Filtering Medium
- •Sulfate Sludge Fixation
- •Sand Blasting Grit
- •Ice Covered Road Grit
- •Agricultural Fertilizer
- •Artificial Reef Construction
- •Portland Cement Manufacture

TABLE 2

Options to Reduce or Manage Solvent Wastes. The waste reduction options at the top of the table are preferred; disposal is used to eliminate residual wastes.

Waste Management Options	Examples	Key Issues/Potential Problems
Reduce Solvent Use	Add covers to parts cleaners Install countercurrent, multi-stage cleaners Use "universal" solvent	Usually inexpensive Requires operator and worker involvement and training May reduce worker exposure
Substitute Non-Hazardous Materials	Use non-hazardous citrus, alkali or emulsion cleaners Use bead or sand blasting for parts cleaning	Aqueous substitutes less costly, organic substitutes more costly Substitutes may not perform as well as traditional solvents
Recycle Spent Solvent	Solvent and parts cleaner contract services On-site recycling Off-site (commercial) recycling	Recycling appears cost effective Solvent contract services minimize utility involvement On-site recycling requires large volumes to be economic
Solvent Waste Disposal	Hazardous waste incineration Waste derived fuel and fuel blending Burn waste in utility boiler	May be only alternative for some waste materials Regulatory uncertainty about burning as fuel

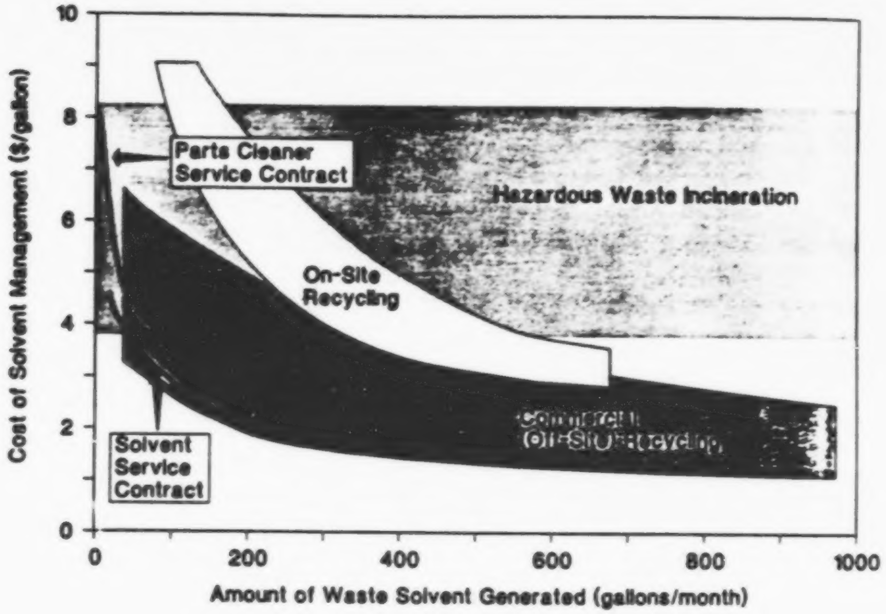


FIGURE 2

Comparative Costs for Waste Solvent Recycling

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COAL REFUSE TO ENERGY

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Abstract

The objective of this research is to develop basic energy production and environmental information for the in-situ combustion of coal refuse piles. Laboratory pilot system results show exhaust gas temperatures from in-situ combustion of over 1,000°C, with 65% to 96% utilization of the original calorific content of the pile. The relative quantity of fines has great influence on gas permeability of refuse, and operational efficiency of combustion. EPA-TCLP leachates of "post burn" coal refuse are nonhazardous under current RCRA regulations. Combustion volatilized significant quantities of Al, Pb, Zn, Hg, and Cd, and removed 40% to 99% of the original pyritic sulfur, thereby attenuating acid mine drainage potentials.

KEYWORDS: Coal refuse; waste-to-energy; combustion; leachates; coal preparation plants; trace metals;

COAL REFUSE PILES: NATURE, LOCATION, SAMPLING

Coal refuse piles originate from the coal preparation plant waste residuals of yesterday. It is estimated that about 40% of the volume of all coal mined in the U.S. since the 18th century has been discarded as waste, covering about 177,400 acres of land throughout the coal producing regions of the U.S. Today, coal preparation plants are somewhat more efficient and produce waste at the rate of about 25% by volume of coal feed (1,2,3).

Coal refuse piles contain coal, carbonaceous shales, and pyrites. Some piles are on fire, and pose inherent safety hazards; acid mine drainage conditions are also common resulting in environmental blights on the landscape. Little data is available characterizing the physical and chemical properties of coal refuse piles.

Pennsylvania Department of Environmental Resources (DER) provided topographic maps with locations of all known coal refuse piles within the State. Using this data, a sampling protocol was developed, and 9 different sites were evaluated within the Western Pennsylvania region.

COAL REFUSE ANALYSIS

Samples from each site were crushed and riffled to assure samples were representative for analysis. Coal refuse and ashed refuse samples were digested with HCl and HF in teflon lined vessels for subsequent metal analysis. Details of analytical techniques may be found in Schmidt(4).

Table 1 is a summary of analysis conducted on 9 different coal refuse pile sites in Western Pennsylvania. Results of the 9 sites show a sample mean value of 4,923 BTU/lb dry weight (with a range of 2,328 BTU/lb to 7,187 BTU/lb).

TABLE 1

ANALYSIS WESTERN PENNSYLVANIA COAL REFUSE PILES

Site	BTU/LB.	% ASH	% VOLATILES	%FIXED CARBON
Banning	4,380	65.6	18.7	15.8
Brownstown	7,178	48.2	23.4	28.3
Cramer	6,467	53.6	19.9	26.6
Export	3,665	68.4	17.4	14.2
Homer City	5,844	57.4	18.9	23.6
Mather	3,117	71.9	17.6	10.5
Nemacolin	2,328	76.5	17.1	6.4
Revloc	6,518	51.1	18.6	30.3
Ebenezer	4,8710	63.0	21.5	15.5
Range	*2,328 - 7,178*	*48.2-76.5*	*17.1-23.4*	*6.4-30.3*

Table 2 is a summary of sulfur forms in coal refuse. Note that the *average* total sulfur content is 1.08% (with a range of 0.58% to 3.04%). Further elemental characterization data is provided by Neufeld (5).

TABLE 2

SULFUR FORMS IN WESTERN PENNSYLVANIAN COAL REFUSE PILES
(% BY WEIGHT)

Site	Total	=	Organic	+	Pyritic	+	Sulfate
Banning	.60		.32		.06		.22
Brownstown	3.04		1.32		1.20		.52
Cramer	1.11		.64		.13		.34
Export	.61		.36		.06		.19
Homer City	.79		.39		.09		.31
Mather	.97		.24		.07		.66
Nemacolin	1.59		.17		.12		1.30
Revloc	.91		.37		.05		.49
Ebenezer	.58		.30		.09		.19
Range	*.58-3.04*		*.17-3.02*		*.05-1.20*		*.19-1.30*

COAL REFUSE RECYCLING

Coal refuse is attractive for recycling due to its BTU value. Currently, modular coal preparation type plants using "float/sink" technology are reclaiming some coal refuse sites. Using such technology, a high BTU value coal product may be "mined" for blending with the coal feed to local utility plants. Wastes from such systems are simply returned to the refuse pile. Alternatively, coal refuse may be combusted in bulk for energy production. Two techniques for direct firing include fluidized bed combustion, and in-situ combustion (4,5,6).

Insitu Combustion: Experimental Procedure Figure 1 is a diagram of the University of Pittsburgh in-situ combustion system capable of handling a 25 pound charge of coal refuse. The combustor exhaust pipe was connected through a gas cooling system, to an exhaust fan capable of pulling 75 cfm at a water head of 50 inches. The purpose of the coolers were NOT to generate steam, but rather to cool gases sufficiently to assure the integrity of down stream air pollution sampling equipment, and the air moving fan.

RESULTS

Figure 2 is an example of data from the in-situ combustion of coal refuse from the "Cramer" site. Note exhaust gas temperatures rapidly reached a maximum of 946°C before it declined due to completion of combustion. The temperature profile of the exhaust gas and the lower elevation of the reactor follows similar trends. Further data of a series of runs comparing refuse of high and low ash contents shows that high ash content material could also achieve substantial exhaust gas temperatures and energy production, and therefore should not be ruled out for commercial considerations (4).

GAS PERMEABILITY/PARTICLE SIZE

The particle size distribution of the refuse influenced permeability, which in turn influenced time for startup, and fraction of calorific value recovered during a run. Summary data of runs from all locations shows that start-up periods appears to fairly constant at permeability values greater than about 300 Darcys, with drastically increased values at smaller permeabilities. Further analysis shows that permeability and start-up period increase drastically as the "D-90" particle size (ie.. the effective diameter at which 90% of all particles are larger than) falls below 0.6 mm. Higher permeability allows more air to flow into the fire zone, which, in turn, feeds more oxygen to the fire and avoids pyrolysis conditions.

Gaseous Pollutant Concerns

An air pollution sampling train was installed to monitor on-line SO_2, NO_x, combustion gases, and total hydrocarbons. In general, the nature of air emissions is a function of the type of combustor used. In this case, in-situ combustion is by nature a fuel rich system, with operator control only with the exhaust air fan. Summary data shows a sharp increase in Total Hydrocarbons in the exhaust gas as its temperature decreases below 600°C. Similar data for CO illustrates the same critical temperature. Operation at lower temperatures resulted in pyrolysis conditions, and emission of tars and oil that coated the fan impeller blade. Maintenance of exhaust gas temperatures over 600°C allowed for relatively clean burning of coal refuse with no noticeable hydrocarbons.

Similarly, noticeable levels of H_2S were liberated under lower temperature/pyrolysis conditions with SO_2 being liberated at elevated temperatures. Analysis shows some sulfur oxide controls would be necessary for commercial scale in-situ coal refuse combustors.

Trace Metals:

Material balances conducted for trace metals shows that significant fractions of Cd, Pb, Hg, Al, S, and Zn appear to be volatilized during coal combustion: the data for the significant fractions volatilized is presented in Table 3.

TABLE 3

ELEMENTS VOLATILIZING DURING COAL REFUSE COMBUSTION
"Percent Volatilized"

Site	Cd	Pb	Hg	Al	S	Zn
Banning	75.0	79.3	71.7	0	83.3	69.9
Brownstown	28.6	81.1	83.8	4.8	71.4	39.4
Cramer	66.7	72.0	92.4	0	76.6	20.0
Export	0	73.2	76.6	33.3	82.0	0
Homer City	50.0	59.6	72.7	25.3	77.2	41.7
Mather	53.8	91.7	68.8	21.8	76.3	10.6
Nemacolin	12.5	91.7	81.3	23.3	57.9	0
Revloc	50.0	87.2	81.8	21.2	65.9	0
Ebenezer	78.1	85.7	40.7	22.2	75.9	33.9
Range	0-78	60-92	69-96	0-33	58-83	0-70

Normalizing quantities of metals released to energy production, Table 4 shows calculated air emission potentials for key volatilized trace metals as follows:

TABLE 4

AIR EMISSION POTENTIALS FOR
Al, Cd, Hg, Pb, and Zn

Element	Range (lbs. of metal/100 MW day)
Al	0-407,500
Cd	0-2.3
Hg	1.0-10.1
Pb	150-395
Zn	0-516

Similarly, elements Ba, Fe, Mn, Ca, and Mg appears to be retained strongly in the combustion ash. Results of a mass balance showing "percent retained in ash" of these elements is given on a site-by-site basis on Table 5. This data was developed by acid solubilization of aliquots of pre and post burn coal refuse samples, followed by AA analysis for metals of concern.

TABLE 5

ELEMENTS RETAINED IN COAL REFUSE COMBUSTION ASH
"Percent Retained in Ash"

Site	Ba	Fe	Mn	Ca	Mg
Banning	100	100	100	100	93.3
Brownstown	100	100	100	78.3	92.3
Cramer	100	100	100	100	100
Export	96.1	91.5	100	80.0	96.3
Homer City	99.5	76.8	100	100	86.0
Mather	97.5	95.0	100	89.4	91.4
Nemacolin	100	83.7	100	100	94.1
Revloc	100	94.7	100	60	100
Ebenezer	92.1	84.2	100	55	86.7
Range	92-10	84-100	100	53-100	87-100

LEACHATES and ACID MINE DRAINAGE POTENTIALS:

Pre-burn and post burn coal refuse samples were leached in accord with both the *ASTM distilled water*, and *EPA-EP acetic acid based* techniques. In addition, measures of pH, Hot Acidity, and major anion and cation species were made on the distilled water leachates. Heavy metal based "EP-toxicity" appears not be an issue. Other data, however show that *on the average* the pH of leachate solutions changed from clustering about pH = 3.4 to clustering about pH = 7.2. This is significant, since it indicates that one **beneficial environmental effect of coal refuse combustion** is to cause drainages to go from the acid range, to the neutral/slightly alkaline range. This is a particular advantage for in-situ combustion where the refuse is not moved.

A better measure of attenuation abilities of acid mine drainage potentials is the "net alkalinity", (Net Alkalinity = Alkalinity - Hot Acidity), which accounts for the ultimate oxidation of inorganic species. Distilled water leachates from combusted coal refuse ash confirm that relatively acidic leachates are converted into a neutral leachates, with concurrent small increases in solubilization of K, Mg, and Na.

A summary compositional analysis of all pre and post burn coal refuse ash is developed for all sites, and is available from Neufeld (5).

CONCLUSIONS:

1. Coal refuse originated as reject material produced during the mining or beneficiation of coal. These wastes pose potentially major environmental problems in the form of fire potentials, and producers of acid mine drainage. Structural weaknesses in coal refuse banks have led to landslides leading to loss of human life. In addition, burning refuse piles contribute significantly to potentially serious air pollution problems, and may cause additional underground coal fires within the coal mining regions of the U.S.

2. One approach for the simultaneous generation of energy, remediation of serious environmental problems, and recycling of resources is combustion of coal refuse via fluidized bed reactors, or via an in-situ technique.

3. Using a bench scaled in-situ combustion technique, Exhaust temperatures in excess of 1,300 °C were easily achievable, however, overall energy utilization efficiencies were achievable only when piles did not contain excessive quantities of "fines. Particle size and the permeability of the refuse are significant variables that influence "extractability", or energy utilization (% of the original BTUs utilized) of a pile. Below a D90 particle size of 0.50 mm (*ie..90% by weight of coal refuse has a particle size > the D90 size*), the energy utilization of the burn decreases from 90+ % to less than 65%. Particle size is related to gas flow permeability. In a similar manner, at gas flow permeabilities of 200 Darcys or less, the energy utilization of the burn follows a similar trend.

4. Leachates produced by the residual material remaining after combustion do not contain metal concentrations in excess of 100 times the drinking water standard and therefore the residual ash material from Burnout Control *would be non-hazardous under RCRA regulations*. Pre-burn coal refuse material exhibited tendencies to acid mine drainage formation as measured by "net alkalinities" *(net alkalinity = alkalinity - hot acidity)*. These tendencies were usually confirmed by visual observation at the time of sampling by the Principal Investigator and research team. Net alkalinities of pre-burn materials ranged from -524 mg/L as $CaCO_3$ to -14 mg/L as $CaCO_3$. Leachates from post combustion residuals were characterized by a net alkalinity range of -12 mg/L as $CaCO_3$ to 36 mg/L as $CaCO_3$ and a pH range of 4.8 to 10.1.

5. Based on the results of mass balances, fractions of Al, Cd, Hg, Pb, and Zn are volatilized during coal refuse combustion. Up to 33% of the solid phase aluminum volatilized, aluminum being present in the solid phase from 6.3% to 9.1% by weight. Cd, Hg, Pb, and Zn were found to volatilize to as high as 70% by weight, however, in the solid phase Cd, Hg, Pb and Zn are present at <.01% by weight.

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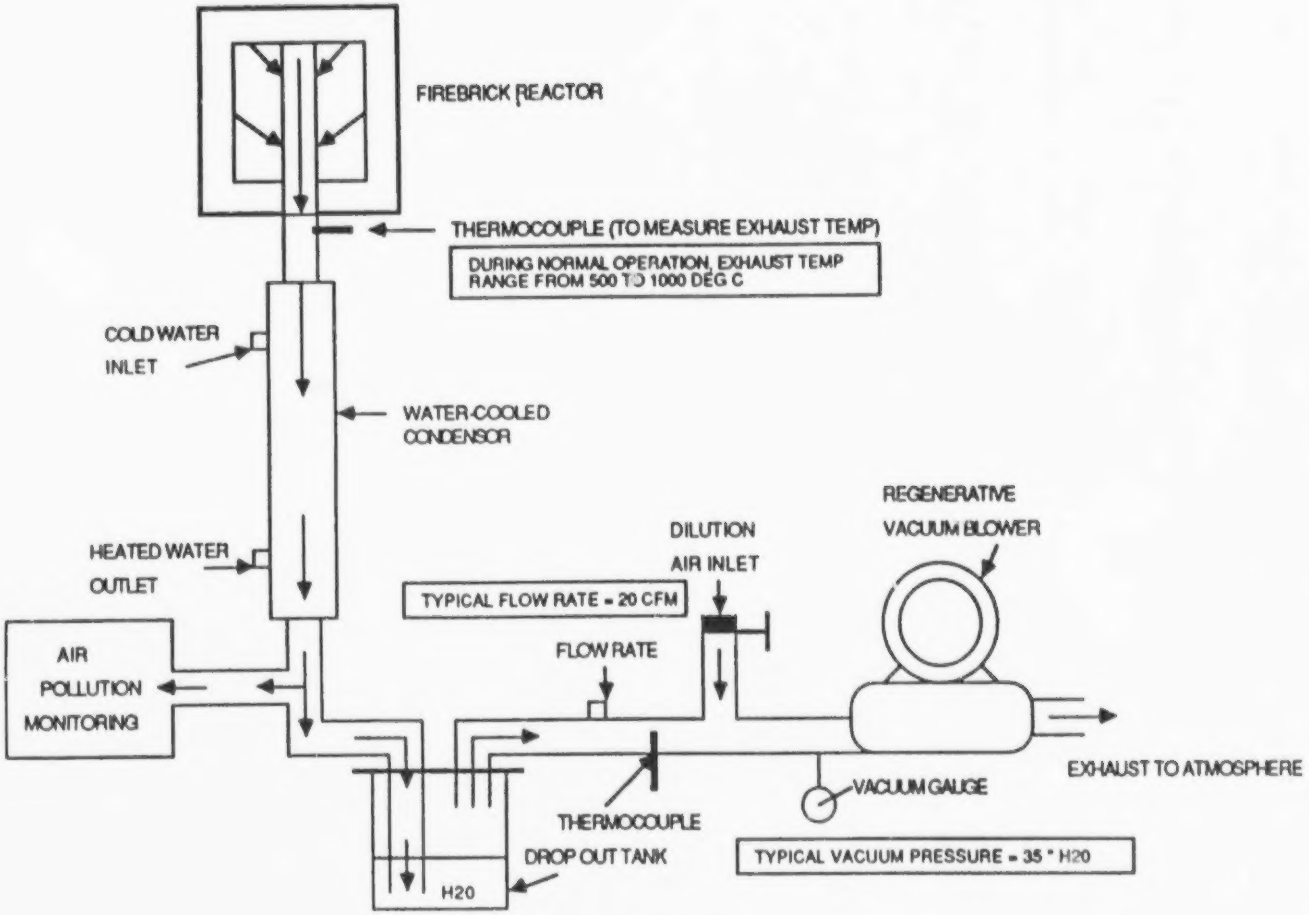
This project, entitled **BURNOUT CONTROL AND ENERGY PRODUCTION FROM COAL REFUSE PILES**, *was supported by the* **Pennsylvania Energy Development Authority** *award number ME 486-004, to the University of Pittsburgh, Dr. Ronald D. Neufeld, Principal Investigator.*


FIREBRICK REACTOR
THERMOCOUPLE (TO MEASURE EXHAUST TEMP)
DURING NORMAL OPERATION, EXHAUST TEMP RANGE FROM 500 TO 1000 DEG C
COLD WATER INLET
WATER-COOLED CONDENSOR
HEATED WATER OUTLET
AIR POLLUTION MONITORING
TYPICAL FLOW RATE = 20 CFM
DILUTION AIR INLET
FLOW RATE
REGENERATIVE VACUUM BLOWER
EXHAUST TO ATMOSPHERE
VACUUM GAUGE
THERMOCOUPLE
DROP OUT TANK
H20
TYPICAL VACUUM PRESSURE = 35 " H20

BURNOUT CONTROL SYSTEM
FIGURE 1

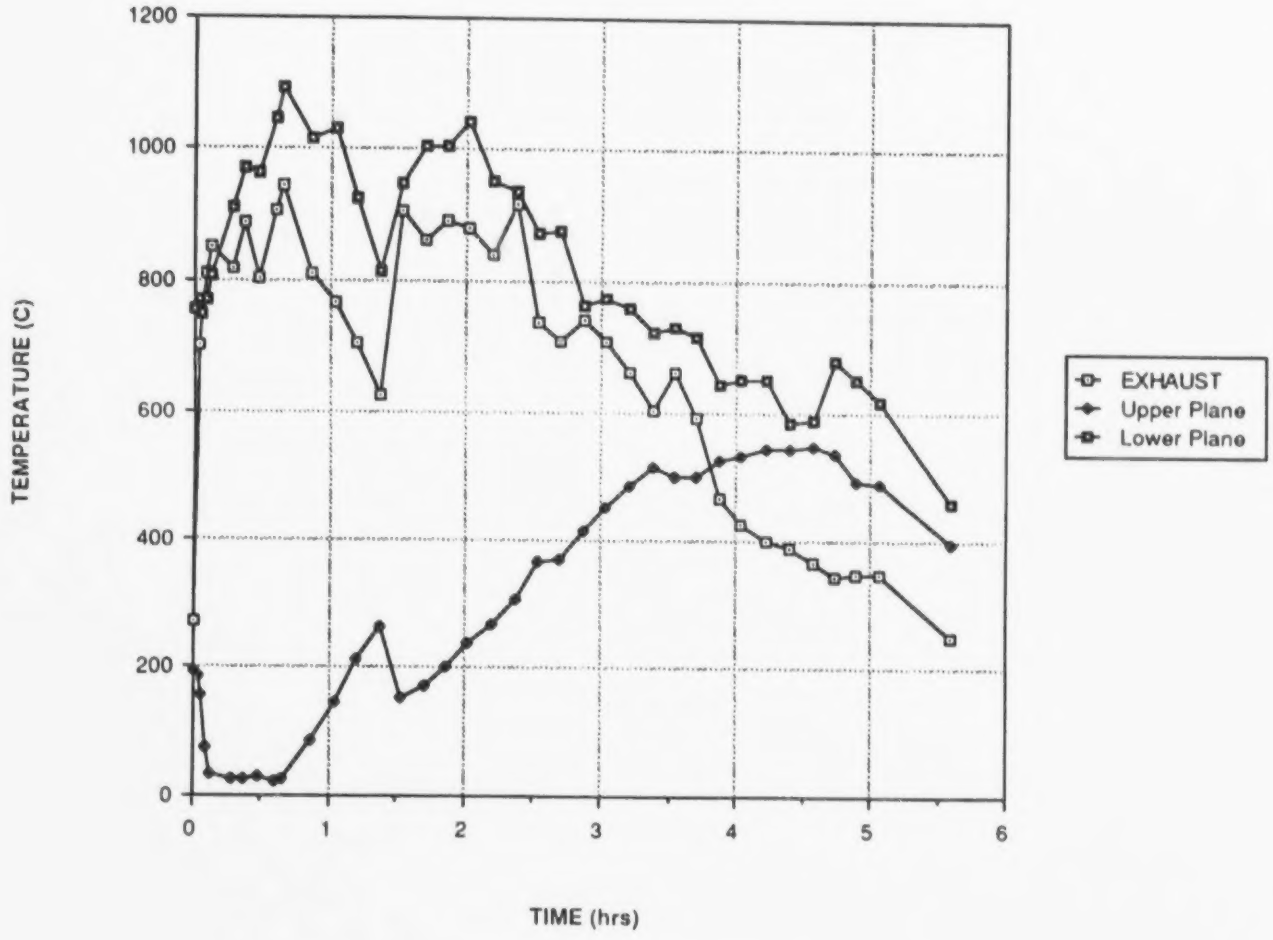


FIGURE 2 TEMPERATURE PROFILE

CRAMER PR-301

SANDIA'S SEARCH FOR ENVIRONMENTALLY SOUND CLEANING PROCESSES FOR THE MANUFACTURE OF ELECTRONIC ASSEMBLIES AND PRECISION MACHINED PARTS

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ABSTRACT

As part of the DOE's commitment to minimizing waste at the national laboratories and its production agencies, Sandia has embarked on a program to reduce, and where feasible, eliminate hazardous liquid waste by-products of cleaning processes used in the manufacture of electronic assemblies and precision machined parts. The program is being carried out in conjunction with three DOE production agencies: Allied Signal-Kansas City Division, EG&G Mound Applied Technologies, and General Electric Neutron Devices Department. We will discuss the methodology used to coordinate such a program across the DOE complex, involving, as it does, hundreds of components and thousands of DOE-specified cleaning processes.

We will also discuss three specific projects to replace chlorinated solvents in cleaning manufacturing processes: 1) alternative solvents used to remove solder flux residues during electronics assembly manufacture, 2) alternative solvents used in ceramic header fabrication, and 3) alternative manufacturing processes that eliminate the need for solvent cleaning of precision optical components prior to mounting.

INTRODUCTION

Chlorofluorocarbon and chlorinated hydrocarbon solvents are widely used throughout the Department of Energy (DOE) weapons complex for cleaning processes. However, due to a variety of environmental, safety, and health concerns, increasing numbers of regulations are being issued by federal, state, and local regulatory agencies to ban, or to place more stringent controls on, the production, use, and disposal of these materials. Since November 1986, DOE/Albuquerque Operations Office (DOE/AL) has been concerned about the use of these solvents within the DOE weapons complex. At that time, R. G. Romatowski, Manager, DOE/AL, drafted a memo to all weapons design laboratories and production agencies requesting that they identify and qualify alternate materials to replace the chlorofluorocarbons (CFCs) and chlorinated hydrocarbon solvents (CHCs) then in use.[1] As a result of this request, the design laboratories and production agencies have initiated studies to reduce and eventually eliminate the use of these materials. Sandia National Laboratories (SNL) in conjunction with three DOE production agencies [Allied Signal-Kansas City Division (AS-KCD), EG&G Mound Applied Technologies (EG&G Mound), and General Electric Neutron Devices Department (GENDD)] has embarked on a program to eliminate these materials from cleaning processes used in the manufacture of electronic assemblies and precision mechanical parts. This program represents an enormous undertaking as it will require changes in cleaning processes for hundreds of DOE components.

DOE/AL CHLORINATED HYDROCARBON SOLVENTS COORDINATING COMMITTEE

In response to the Romatowski memo of November 1986, the Chlorinated Hydrocarbon Solvents Coordinating Committee (CHSCC) was created under the auspices of DOE/AL to coordinate solvent substitution efforts, for chlorinated hydrocarbons and chlorofluorocarbons, within the weapons complex. In the three and a half years that this committee has been in existence, there have been significant decreases in the use of these materials in the weapons complex. These decreases have occurred primarily in the area of "non-specified" cleaning processes. Non-specified cleaning processes are those cleaning processes that are not controlled by design laboratory QA specifications and as such are the province of the production agencies. In contrast to non-specified cleaning processes, specified cleaning processes are defined by the responsible design laboratory to ensure that the final product meets or exceeds required performance characteristics.

FIRST INTEGRATION WORKSHOP ON WASTE MINIMIZATION: NON-NUCLEAR COMPONENTS

Realizing that solvent substitution in specified cleaning processes and a number of other waste minimization issues would require a much closer collaboration among the design laboratories and production agencies, SNL hosted the First Integration Workshop on Waste Minimization: Non-Nuclear Components in September 1989. This workshop specifically addressed waste minimization issues affecting non-nuclear components since SNL component design responsibilities lie almost exclusively within the non-nuclear area. During this workshop, working sessions were held which addressed the following areas: 1) Encapsulants; 2) Halogenated and Flammable Solvents; 3) Volatile Organic Compounds (VOCs); 4) Electroplating; and 5) Reliability Assurance (i.e., the need to assure long-term reliability while implementing changes in the four materials areas). The joint SNL/production agency solvent substitution programs that will be discussed here shortly were, in part, an outgrowth of this workshop.

SOLVENT SUBSTITUTION METHODOLOGY

As with any technical endeavor, an organized approach is necessary in order to assure any kind of success. The methodology that we have used in our solvent substitution efforts consists of the following six steps: (1) Survey and periodically update solvent usage; (2) Identify and prioritize user locations and programs; (3) Identify, evaluate, and develop substitute materials/processes; (4) Determine the effects of substitute materials/processes on components and production process; (5) Review proposed material/process changes with the appropriate design and production departments; (6) Implement material/process changes.

SNL/PRODUCTION AGENCY SOLVENT SUBSTITUTION PROGRAMS

In establishing joint solvent substitution programs between SNL and the various production agencies, it was decided that the production agency having primary responsibility in a given component area would be the focus for efforts within that area. Based upon this premise, we have divided up the component areas as follows: 1) Electronic assemblies - AS-KCD; 2) Precision mechanical assemblies - AS-KCD and GENDD; 3) Glass and ceramic components - Mound and GENDD; and 4) Optical components - GENDD. In addition to the above joint SNL/production agency programs, we also have a program with Babcock, Inc. (Orange, CA), a relay manufacturer, and are preparing a joint program with Raymond Engineering (Cromwell, CT), a manufacturer of inertial switches. Both of these companies are small vendors who do not have the resources necessary to undertake these solvent substitution studies on their own. The successful completion of these programs will represent a transfer of technology from DOE to these two companies in the private sector. Three joint SNL/production agency solvent substitution programs for the cleaning of electronic assemblies (AS-KCD), ceramic components (Mound), and optical components (GENDD) will now be discussed.

SOLVENT SUBSTITUTION STUDIES FOR ELECTRONICS ASSEMBLY CLEANING AT AS-KCD

At this time, SNL and AS-KCD are involved in a joint solvent substitution study to replace trichloroethylene (TCE) in the cleaning of electronics assemblies at AS-KCD. Figure 1 shows a typical electronics assembly that illustrates the potential size and complexity of the assemblies that must be cleaned.

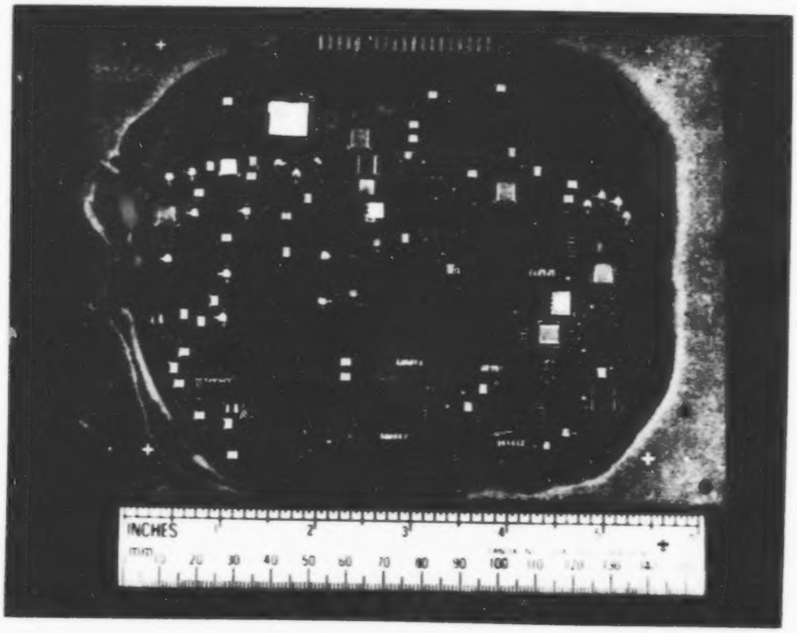

Figure 1. AS-KCD electronics assembly.

This study is focussed on a system that contains eight major electronics assembly modules. Production of this system requires 49 separate solvent cleaning steps using TCE. These cleaning steps are primarily for in-process rosin flux removal, cleaning of completed subassembly and assembly modules prior to foam encapsulation, and post-encapsulation cleaning of silicone mold release from encapsulated units.

In this study five substitute cleaning materials; a terpene, decyl acetate, two proprietary aqueous cleaners, and isopropyl alcohol, are being evaluated as potential replacements for TCE. This study has been divided into two phases: Phase 1 is an initial screening process to narrow down the list of substitutes to one or two cleaners; Phase 2 is further evaluation and process development studies of the cleaner or cleaners that successfully pass Phase 1 evaluation testing. After successful completion of the Phase 2 studies, a substitute material will be qualified to replace TCE in production cleaning processes.

At this time, Phase 1 testing has been completed. Evaluation criteria that were used in the Phase 1 screening process were: ES&H impact at AS-KCD, cleaning efficacy, cleaner corrosivity, bondability of cleaned surfaces, and high voltage breakdown resistance of high voltage assemblies after cleaning. The bondability and high voltage breakdown resistance testing were necessary due to specific issues related to the production and function of this particular system.

An ES&H impact assessment was done by environmental, fire safety, and industrial hygiene personnel at AS-KCD. This assessment indicated that, properly used, none of the five substitute materials would present a significant ES&H problem with either current or anticipated near term regulations.

Cleaning studies were carried out at both SNL and AS-KCD. The SNL studies were primarily focussed on the removal of solder flux and silicone mold release agent from four substrate materials common to the electronics system being cleaned. These materials were: bare copper, bare copper which had been fluxed and Sn/Pb solder dipped, 17-4 PH stainless steel, and E-glass/polyimide printed wiring board material. The bare copper and solder dipped copper substrates were used to simulate electronics materials before and after soldering. The 17-4 PH stainless steel is used as the structural housing material for the electronics assemblies and the E-glass/polyimide printed wiring board material is used in all of the electronics assemblies in the system.

In this study, coupons of the four substrate materials were contaminated with each of the two contaminants; the mildly activated solder flux and the silicone mold release agent. These coupons were then cleaned using TCE, to provide baseline information, and the five substitute cleaning materials. After cleaning, the coupons were analyzed to determine cleaner efficacy for each combination of substrate, contaminant, and cleaner.

Solder flux contaminated coupons were analyzed visually and with Auger electron spectroscopy (AES) or x-ray photoelectron spectroscopy (XPS) to identify and quantify surface contaminants. An additional set of solder dipped copper coupons were analyzed using an Omegameter to measure residual ionic contamination levels. All silicone mold release contaminated coupons were analyzed visually and with AES or XPS. In addition, goniometer water drop contact angle measurements were made and used to determine relative surface cleanliness levels.

In addition to the above SNL cleaning study, cleaning studies were also carried out at both AS-KCD and SNL to determine the effectiveness of the TCE and substitute cleaners in removing some of the general contaminants present in the production area. These studies were done on bare copper, bare aluminum, and solder dipped copper substrates using various oils, greases, mold release and body oils. Cleaning efficacy in these studies was determined visually, by weight loss measurements, MESERAN (Measurement and Evaluation of Surfaces by Evaporative Rate ANalysis) values, water drop contact angle measurements, and Grazing Angle Reflectance-Fourier Transform Infrared Spectroscopy.

Analysis of data from all the SNL and AS-KCD cleaning studies indicated that, of the five substitute cleaners, the decyl acetate and terpene cleaner were the most effective in removing the solder flux, mold release agent and other contaminants that were studied. This data also showed that the decyl acetate and terpene cleaner both cleaned as well as TCE in these studies.

Two types of tests were conducted at SNL to evaluate the relative corrosivity of the substitute cleaners and TCE. The first of these tests was an immersion test to determine the aggressive nature of each of the cleaning solutions. In this test, preweighed coupons of copper and Sn/Pb solder were immersed in each of the cleaners for one week, at ambient temperature. At the end of this time, the coupons were removed, rinsed, dried, and reweighed. Relative changes in the weight of the coupons, before and after immersion, provided an indication of the aggressiveness of each cleaner.

The second part of the corrosion evaluation testing was designed to assess potential long-term corrosion problems due to cleaner residues left from incomplete rinsing after cleaning. In this test bare copper and Sn/Pb solder coupons were prepared under no rinse, partial rinse, and full rinse conditions for each of the cleaners. These coupons were then placed in an environmental chamber and aged for 30 days at 40°C, 70% relative humidity. At the end of this time, the coupons were removed and a visual assessment was made of the relative amounts of corrosion present. Results of both the immersion and cleaning residue tests indicated that all five substitute materials were acceptable from a corrosion standpoint.

Post-cleaning bondability of materials was investigated at SNL. In these studies adhesive shear strengths were measured between an encapsulating resin and coupons of solder dipped copper, 17-4 PH stainless steel, and E-glass/polyimide printed wiring board material. In these tests thin-wall steel cylinders were bonded to the cleaned substrates with an encapsulating resin and torqued to failure. Within experimental scatter, TCE and the five substitute cleaners all yielded the same short-term adhesive shear strength. These tests were deemed necessary due to the large number of bonding and encapsulation processes which occur during production of the system.

The final evaluation testing in Phase 1 involved high voltage breakdown testing at AS-KCD. High voltages are present in several modules in the system under study and previous experience had shown that high voltage breakdown problems are often the first indication of incomplete cleaning and/or contamination of these modules. High voltage breakdown testing was done using a high voltage test assembly that had been cleaned using each of the cleaners. After cleaning, the test assembly was subjected to a high voltage stress test to determine breakdown behavior. Results of this testing indicated no significant high voltage breakdown failures due to the use of any of the cleaners.

Based upon all Phase 1 testing, the decyl acetate and terpene cleaner were selected for further evaluation in Phase 2 of the solvent substitution program. The main issues to be addressed in Phase 2 are materials compatibility and the determination of process parameters to be used in production at AS-KCD. These studies are now underway. If either of the substitute cleaners successfully passes the Phase 2 evaluation process, TCE will be replaced with a substitute cleaner.

EG&G-MOUND INVESTIGATION OF SUBSTITUTE CLEANING AGENTS FOR METHYLENE CHLORIDE IN HEADER SUBASSEMBLIES

A cleaning process for the production of header subassemblies at EG&G-Mound utilizes methylene chloride in conjunction with a specified "four step" cleaning solution.

In an effort to eliminate the use of methylene chloride from this cleaning process, four non-chlorinated solvents, N-methylpyrrolidone (NMP), Arco Solv DPM, Bioact EC-7, and ethyl lactate, were evaluated as potential substitutes. Cleaning tests of the four substitute solvents, along with methylene chloride, were conducted using component parts and built-up header subassemblies in the actual production environment. The header subassembly selected for this evaluation is shown in Figure 2. The component parts of this subassembly are: an Inconel 718 shell, two Kovar or Hastelloy 276 pins, and an S-glass preform.

In these tests, groups of fifty parts were processed with each solvent using the "four step" cleaning process. The components and resultant subassemblies were analyzed by Auger

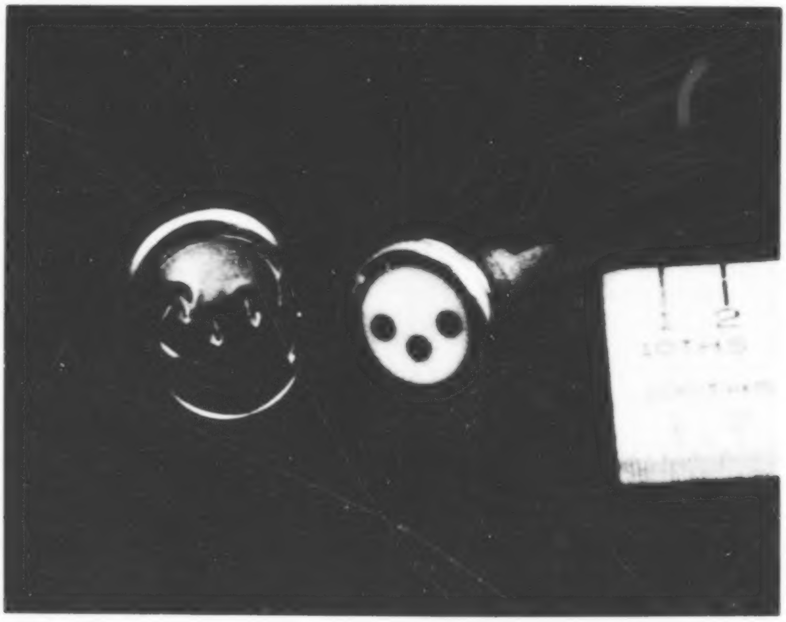

Figure 2. Mound header subassembly.

electron spectroscopy (AES) and x-ray photoelectron spectroscopy (XPS) after six different production process cleaning steps. The cleaning effectiveness of each solvent was determined by comparing the levels of carbon residues measured on the surface of the components and subassemblies before and after the "four step" cleaning. These carbon residue levels, which indicate the amount of organic surface contamination, were assumed to be residual contaminants from the air, contaminants generated during processing, and residues from the cleaning solvents. The data from each group of fifty parts was averaged for each of the six production process cleaning steps. These average values were then used in determining the relative cleaning effectiveness of the methylene chloride and the substitute solvents at each of the six steps.

To illustrate this, Table 1 shows the average carbon levels on glass preforms as received and after "four step" cleaning using the methylene chloride and substitute solvents. The carbon atom percent values listed were reproducible within ±5% of the average value listed, and differences of more than 5 at% are considered significant with respect to residual contamination. Additional data from this study is available in a formal report.[2]

TABLE 1 - AVERAGE CARBON LEVELS OF GLASS PREFORMS

Glass Preform Sample	Carbon (at.%)
As received	36.0
Methylene chloride/4-step cleaning	27.0
EC-7/4-step cleaning	15.7
NMP/4-step cleaning	14.7
DPM/4-step cleaning	38.4
Ethyl lactate/4-step cleaning	20.0

An analysis of the glass preform data shown in Table 1, along with the data for the other five production process cleaning steps indicated that, overall, NMP and Bioact EC-7 were superior to methylene chloride for the production cleaning of this header subassembly. At the present time, Bioact EC-7 is undergoing additional evaluation studies at EG&G-Mound.

ELIMINATION OF SOLVENT CLEANING IN OPTICAL COMPONENT SOLDERING AT GENDD

A critical process in producing an optical assembly at GENDD involves soldering a cylindrical shaped, borosilicate glass lens into a Kovar housing using 63Sn-37Pb solder. This lens has a diameter of approximately 1 mm and fits into a correspondingly small cavity in the housing. Figure 3 shows the housing, lens, and solder preform that is used in the soldering process. A critical feature of the lens is a brittle anti-reflective (AR) coating present on both ends of the lens. The outer body of the lens is gold coated, using a Cr/Pt/Au metallization process, to provide a solderable surface. The Kovar housing is also nickel plated for this same reason.

Initially, joining of the lens to the housing was performed by using an activated rosin flux with the solder preform. Although this process produced acceptable solder joints, all flux residue had to be removed after soldering to eliminate the possibility of subsequent corrosion. To remove the solder flux residue, the soldered assemblies were ultrasonically cleaned for 10 minutes in trichloroethylene followed by 10 minutes in isopropyl alcohol. In evaluating this cleaning process, there was a concern that the small size and complicated geometry of the housing might provide "hideouts" where flux could become entrapped and not be removed by the cleaning process.

In order to overcome this concern, an alternative soldering process that substitutes a reactive gas for the activated rosin flux was developed. Pure hydrogen was chosen as the reactive gas and the process that was developed is detailed below. First, the

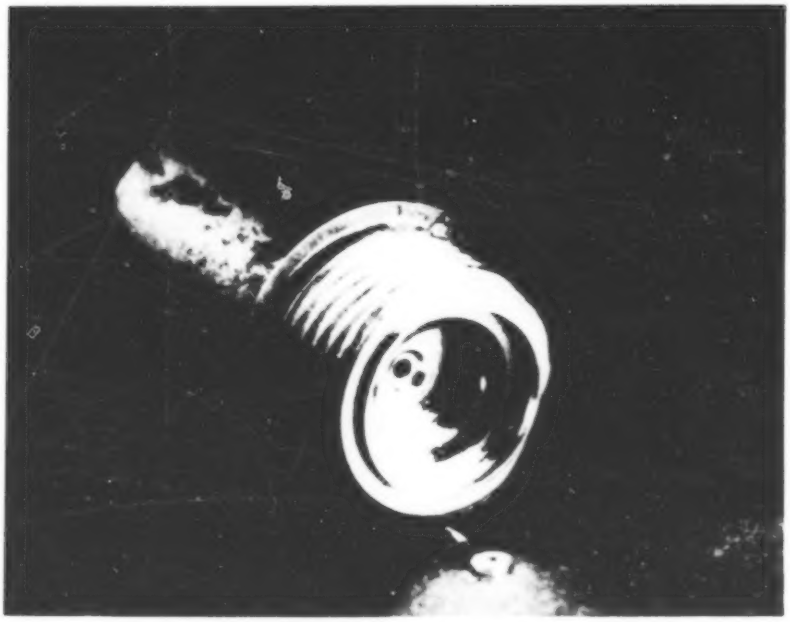

Figure 3. GENDD optical assembly.

nickel-plated Kovar housing is placed in a dry hydrogen furnace at 975°C for 20 minutes to reduce the surface oxides on the nickel. After treatment, the housings are stored in a dry environment and are to be soldered within 24 hours to ensure that excessive reoxidation of the nickel surface has not occurred. In preparation for soldering, the lens and a solder preform are inserted into the housing on fixtures. The housing/lens assembly is then placed in a hydrogen retort furnace where the assembly is heated at 250°C for 20 minutes in hydrogen. At this low temperature, the hydrogen atmosphere provides some additional oxide reduction. Since the gold surface on the lens is not oxidized to begin with, the solder wets the lens well. The cleaned nickel layer on the housing also wets well and the solder easily flows between the lens and the housing via capillary action. The soldering temperature of 250°C is an increase over the 210°C soldering temperature that was used in joining fluxed parts. This temperature increase was necessary to achieve adequate capillary flow and is in no way detrimental to the lens, the AR coatings, or any optical performance.

Optical metallographic analysis of solder joints produced using the reactive hydrogen gas process indicate that these solder joints are as good as those obtained using an activated rosin flux. As an added benefit, the elimination of solder flux from this production process also eliminated the need for solvent cleaning with trichloroethylene and isopropyl alcohol.

SUMMARY

Sandia and its production agencies are committed to waste minimization. As a part of this commitment, joint SNL/production agency programs have been and are now underway to reduce and eventually eliminate CFCs and chlorinated hydrocarbon solvents from production cleaning processes in the DOE weapons complex. These efforts have already been successful in decreasing the amounts of these materials being used and will continue. The desired end result of these efforts will be the elimination of the use of these hazardous materials in the weapons complex while maintaining the same levels of weapons safety and reliability that have been historically achieved.

ACKNOWLEDGEMENT

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RECOVERING VALUE FROM PROCESS WASTES

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ABSTRACT

By-products produced in the manufacture of Nylon 6-6 Intermediates are considered valuable chemicals to be recycled, purified for sale or used as specialty fuels. Three case studies illustrating differing technical approaches, obstacles and commercial resolution will be presented. Propionitrile produced during the electrohydrodimerization of acrylonitrile to adiponitrile is isolated, refined and sold as a raw material useful in the production of di-n-propyl amine. Tricyanohexane, the trimer of acrylonitrile, is produced in the same process. Isolation of this high boiler is straight-forward enough but purification is so difficult as to preclude chemical feedstock uses and relegate it to use as fuel in a hydrogen reformer. High boiling residues from the air oxidation of cyclohexane to cyclohexanol are a prohibitively complex mixture of closely related compounds. The oily mixture is extracted with an aqueous process stream to remove ash forming metals and produce clean boiler fuel.

INTRODUCTION

The United States Chemical Industry is currently experiencing profound change. Motive forces for the current change are a complex blend of social and economic circumstances. Almost two decades ago, Alvin Toffler (1) warned of such an extraordinary impending transformation. Toffler urged creation of refuges to shelter against such perilous inconstancy. Unfortunately, our industry has found no sanctuary for retreat from either the previously unprecedented international competition or the rising tide of public expectations which characterized the last decade.

Corporate policies often resist change; our policy is to minimize this resistance. Our CEO is a proponent of sweeping change. Our corporation has recently adopted a broad policy committing to significantly reduce process wastes and to demonstrate "exemplary performance in all environmental responsibilities." Working toward an ultimate goal of zero discharge worldwide, our company has set a target of 70% reduction in organic and toxic inorganic wastes by the end of 1995. Recovering value from these process wastes is an essential part of implementing this policy.

Effective utilization of chemical byproducts is also an appropriate response to the resource conservation, social responsibility and economic pressures which beleaguer our industry. Utilizing byproducts is recovering "value" from process waste. Adding value is what chemical processing is all about. Today I will share some experiences in recovering value from byproducts produced in the manufacture of nylon, or more specifically, the manufacture of nylon 6-6 salt. The reported results are consequences of group effort by many people and are not personal achievements of myself or of the other authors. Indeed, byproduct utilization seems always the result of protracted, complex and interrelated activities by many different individuals. Such processes seem characteristic of our time.

Experience leads us to propose some heuristic rules to guide the search for value (Figure 1). Certainly the easiest way to handle byproducts is to avoid making them. Many of us have done this for years and called it "yield improvement." Unfortunately many of our chemical processes are rather mature and have had much of the achievable yield improvement quite literally "squeezed out of them." If all else fails, the only acceptable alternative is responsible disposal. I emphasize "responsible"; our society will tolerate nothing less.

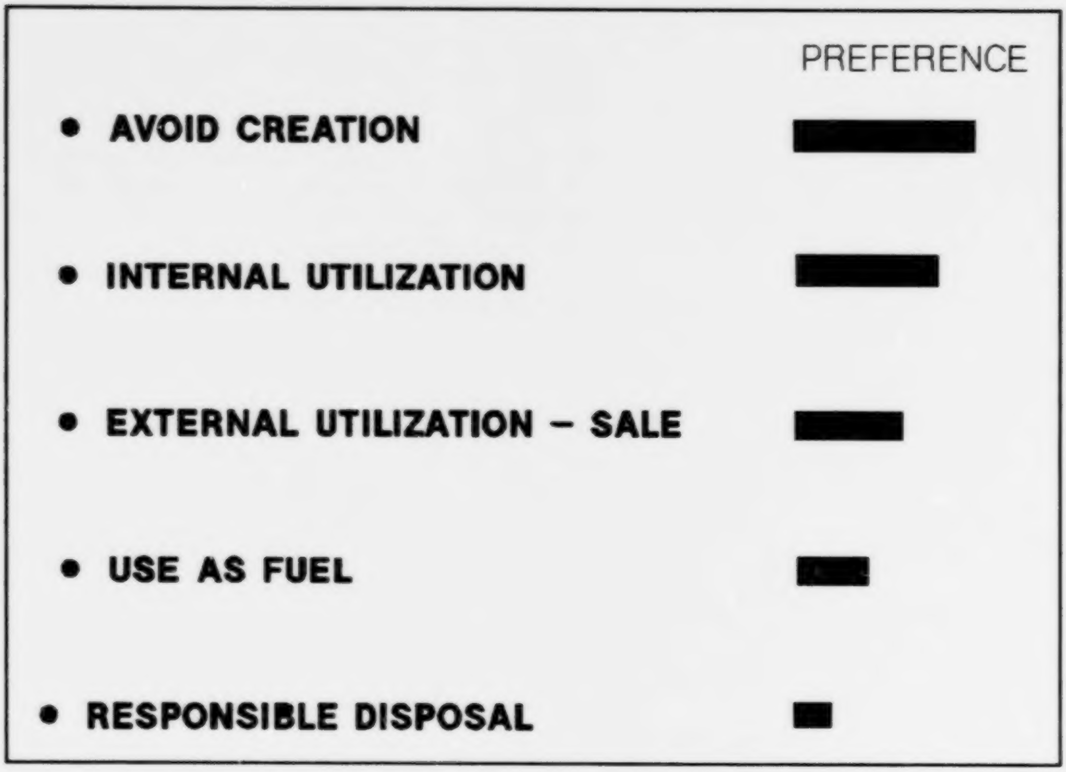


Figure 1. Hierarchy of Waste Minimization Procedures

Between the extremes of avoidance and disposal we must define efficacious alternatives from for implementation. The alternatives should be considered quite broadly. Internal use is usually preferable to external use. This policy conserves resources; it reduces product development, technical service and other marketing costs. Several nylon intermediates byproducts are profitably sold, worldwide, in "as produced," purified and derivatized forms. In general, we recommend limiting byproduct processing to the extent essential for profitable use. Derivitivization usually requires intensive processing and is normally justifiable only if the derivative can be internally utilized.

The principal products and the process itself sometimes suggest possibilities. Our process for producing nylon intermediates is shown in Figure 2. We start with cyclohexane and acrylonitrile to produce adipic acid, hexamethylenediamine and nylon salt together with several byproducts. While this process has unique features, both Monsanto and our principal domestic competitor, DuPont, produce and sell, three directly comparable byproduct materials. These are byproduct dibasic acids from adipic manufacture, shown here as "AGS", residues from the refining of hexamethylenediamine, shown here as "BHMT", and the associated low boiling diamine impurities shown as "Amine Heads." In addition to "as produced" forms, DuPont markets derivatives of the dibasic acids. Development of applications for these byproducts has been previously discussed (2,3). The three byproducts which I will discuss are two produced in the electrohydrodimerization of acrylonitrile to adiponitrile, a process developed by Monsanto, and a byproduct stream produced by the air oxidation of cyclohexane to cyclohexanol.

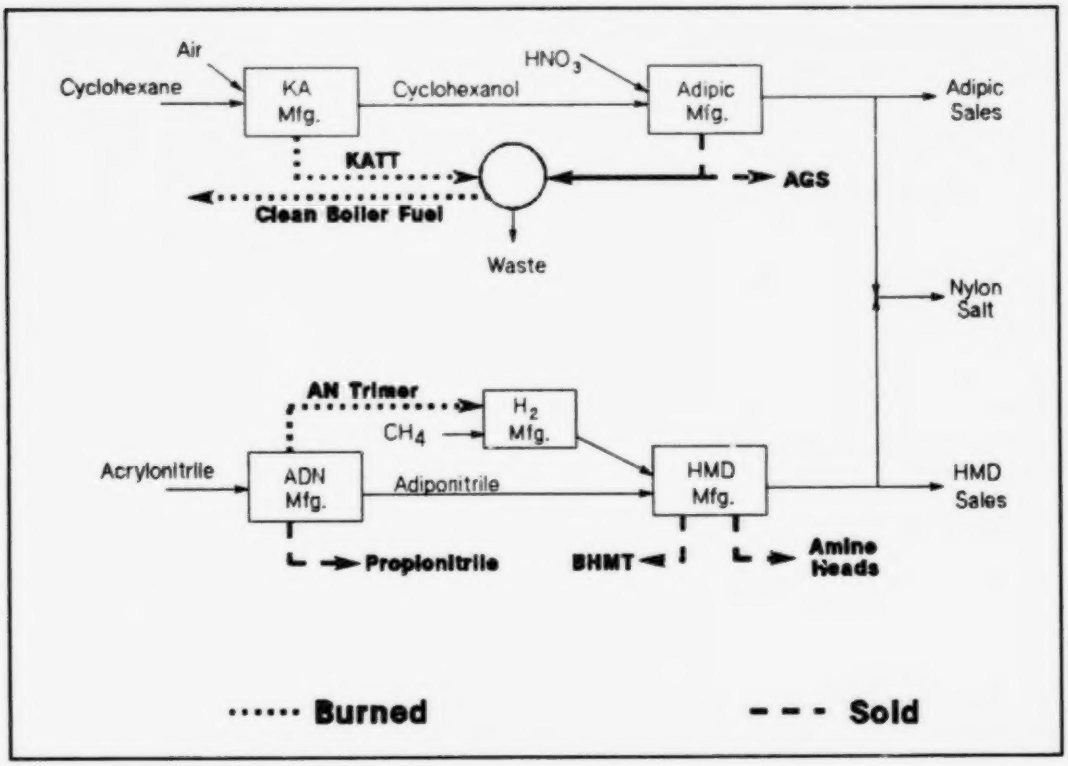


Figure 2. Nylon Intermediates Byproducts

UTILIZATION OF PROPIONITRILE

Propionitrile is one of two major byproducts produced in the hydrodimerization of acrylonitrile (Figure 3). It is readily isolated from the reaction mixture and purified by distillation. Dehydrogenation of byproduct propionitrile to acrylonitrile is a logical route to internal utilization which has been studied in some detail. Unfortunately, the selectivity of dehydrogenation declines with conversion. To obtain high yield, the desired acrylonitrile product must be recovered from a substantial quantity of unreacted propionitrile and the boiling points are relatively close. Economics of this alternative have not been attractive. Hydrogenation to the primary amine, n-propylamine, using an extension of our hexamethylenediamine technology was simple enough. Unfortunately there is virtually no market for this material! The market is for the secondary amine, di-n-propylamine, analogous to the undesired byproduct BHMT in the HMD process!

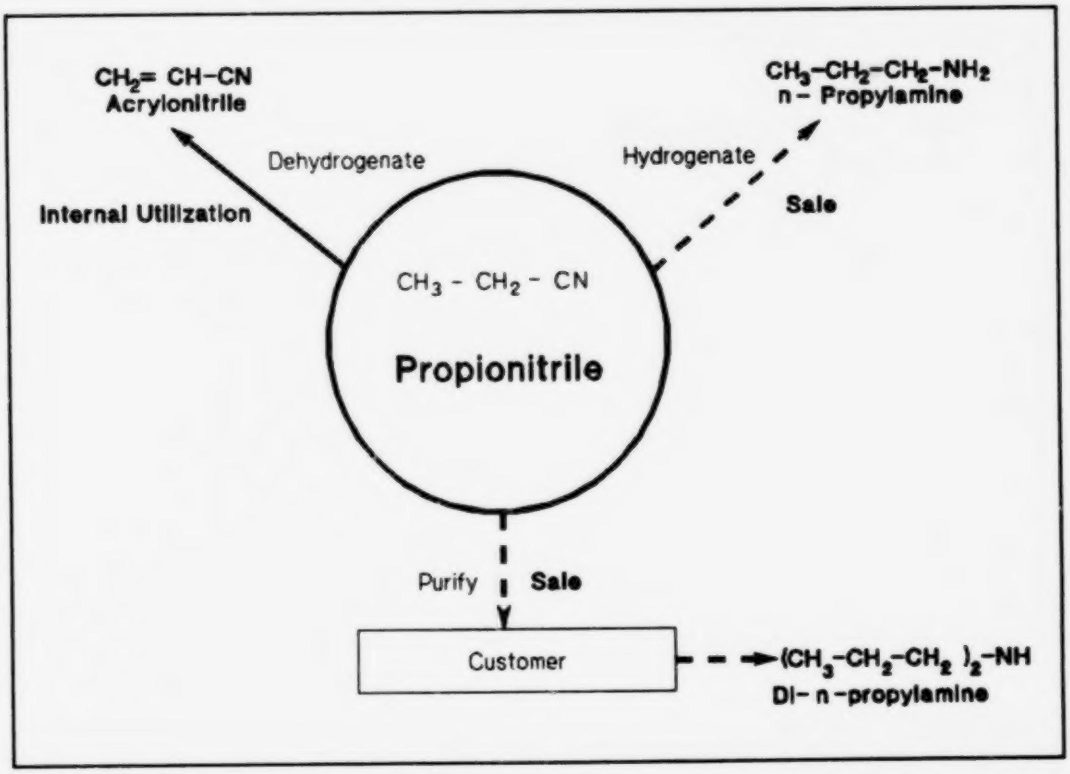


Figure 3. Alternatives for Propionitrile Utilization

The conventional route to di-n-propylamine is by reacting n-propanol with ammonia. The hydrogenation of propionitrile had potential raw material cost advantages over the conventional route, but required different reaction conditions and even the preferred reactor design was considerably different. Protracted cooperative efforts with potential customers well established in the alkylamine business were required before profitable sale of this byproduct was achieved.

UTILIZATION OF AN TRIMER

The other major byproduct from the AN hydrodimerization is the trimer, which we call tricyanohexane (Fitgure 4). Both cracking to adiponitrile and hydrogenation to the triamine have been extensively investigated both by Monsanto and by Asahi, a Japanese practitioner of hydrodimerization. The triamine, in particular, shows considerable promise as a high-value, trifunctional crosslinking agent. Unfortunately either reaction requires purified feedstock; herein lies the problem. The very low vapor pressure of the trinitrile prohibits economic distillation and no satisfactory alternative purification process has been developed.

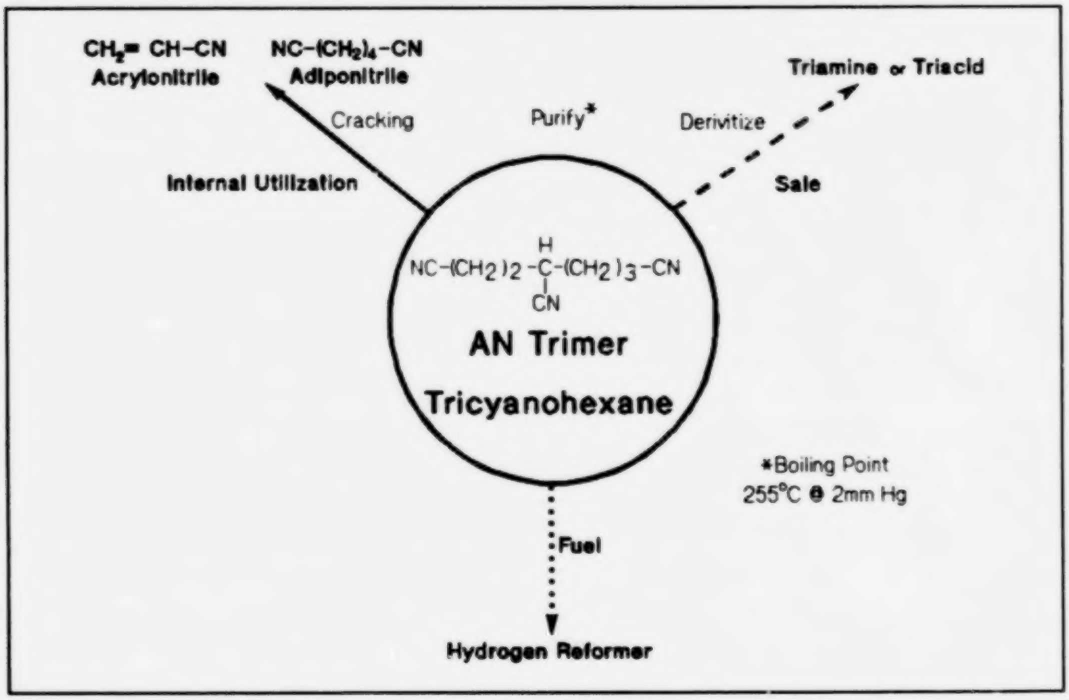


Figure 4. Alternatives for Utilization of Tricyanohexane

The initial suggestion of using this byproduct as reformer fuel was greeted with strident skepticism! (Figure 5). Our reformer was designed to use clean, expensive natural gas as fuel. To many the idea of using this thick, black, "pitchlike" residue seemed irrational. Technical consideration further deprecated the idea. This material contains 25% organic nitrogen which many thought would produce copious NO_x fumes and cracking experiments had previously shown hydrogen cyanide as a degradation product. It also contained solid particles to plug control valves and burner orifices. The most serviceable feature was reasonable heating value.

Tricyanohexane Characteristics

Black Viscous Residue
25% Nitrogen – Solids
Heating Value – 13,800 BTU/lb

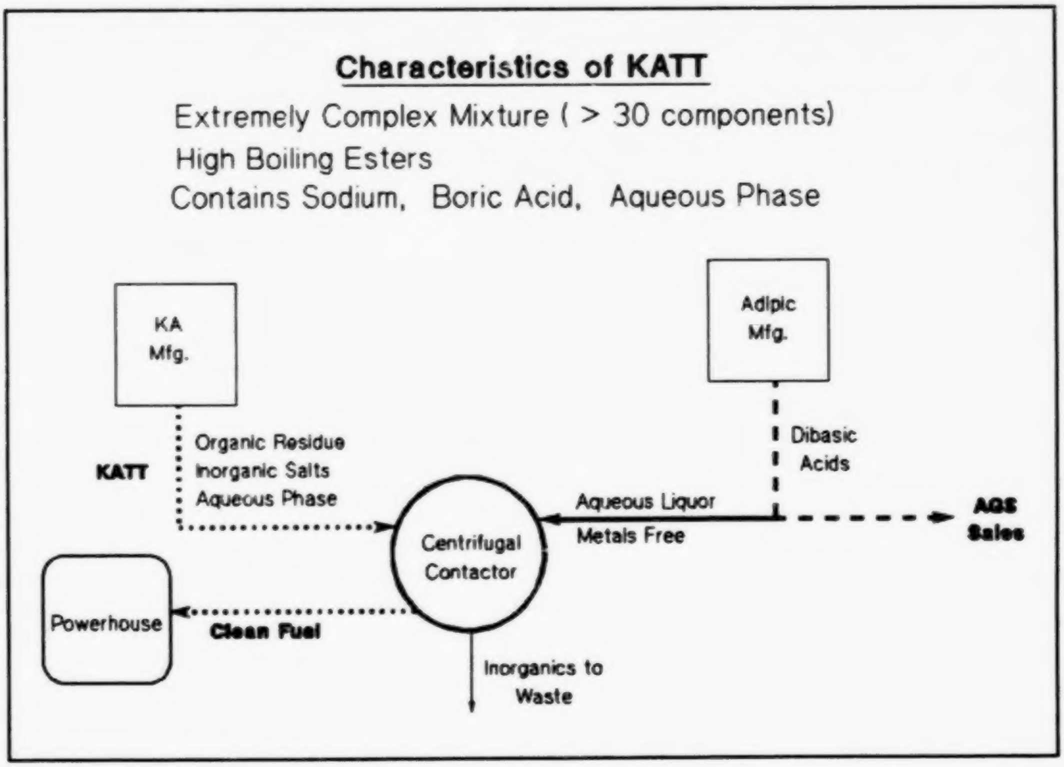
Concern	Resolution
Incomplete Combustion Toxic Stack	Stack Gas Analysis No HCN or Organics Acceptable NO_x
Corrosion	Replaced 25 Cr/20 Ni with 28 Cr/48 Ni Tubes
Fuel Flow Control	Filtered Fuel Heated Lines Resized Valves

Figure 5. Tricyanohexane Utilization Issues

Despite the skepticism, off-plant burner trials were conducted. To the amazement of some, even the most careful stack gas analysis revealed absolutely no HCN or other toxic organics. Under limited oxygen conditions needed for the high-temperature reformer, very little of the fuel nitrogen was converted to NO_x. Subsequently it was learned that another Monsanto scientist (4) had previously investigated combustion of high nitrogen fuels with similar results. Because of modest corrosion after two years, the very old, somewhat outdated reformer tubes were replaced with higher performance, higher nickel alloy. Conventional engineering design changes successfully adapted the system to this alternative fuel. Following almost seven years of successful operation, the burning of high nitrogen organics as fuel has been expanded to the boilerhouse using a combination of waste with pulverized coal. Extensive stack gas sampling has established no increase in NO$_x$ levels and appropriate air quality regulatory agencies have approved the practice.

UTILIZATION OF KATT

The final example illustrates beneficial utilization of two waste streams from different manufacturing areas. One is a distillation residue from refining of cyclohexanol and the other stream a dilute waste liquor from crystallization of adipic acids. Sources of both these purge streams are shown in Figure 6. The high boiling residue from this refining process is called KA Topper Tails, or KATT. Some characteristics of this stream are shown. One important characteristic is its complexity. Unlike the two adiponitrile process streams in which one byproduct predominates, KATT contains mote than thirty different organic compounds. Most are high-boiling esters of cyclohexanol or cyclohexane diol but no single component or group of components is present at sufficient concentration to justify separation.



Characteristics of KATT

Extremely Complex Mixture (> 30 components)

High Boiling Esters

Contains Sodium, Boric Acid, Aqueous Phase

Figure 6. One Byproduct Stream Upgrades Another

Despite its high organic content, as produced, this residue is unsuitable as fuel due to variable water content and high metals concentration. In addition to water dissolved in the oil phase, the stream contains a separate aqueous phase amounting to as much as 50% of the total weight. The density differential between the two phases is small, making consistent phase separation difficult. Even with phase separation, the high sodium and boron content of the oil phase would create boiler corrosion and tube fouling problems if burned in the plant boilers.

A development program was undertaken to find ways to overcome these difficulties. Laboratory screening identified waste liquor from Adipic Manufacturing as having favorable characteristics for consistent phase separation, good metals removal, and minimum loss of organics to the extractant. This waste stream is a dilute form of the commercial byproduct AGS. It is a metal-free, aqueous waste stream with an appropriate density. Batch simulation of 2-stage continuous countercurrent extraction with simultaneous phase separation was conducted. Data from the column test were used for scale up to a full-scale installation. A patent was subsequently granted (5). A centrifugal extractor was used in the plant installation to shorten contact time and minimize chemical reaction between the two streams.

Washed KATT is a clean fuel. Because of the relatively low heating value of the highly oxygenated organics, primary fuel is always fired simultaneously to ensure flame stability. Because of the corrosive nature of this byproduct fuel, special stainless steel burner guns and tips are used in this boiler.

This byproduct utilization process has been in operation for more than six years, saving fuel and reducing waste every year. Value has been created by combining two almost useless materials in a creative way; "value added manufacturing" in every way!

SUMMARY

It is risky to generalize from such disparate examples. Certainly in knowledge there is power. It pays to know all you can about everything you make, both composition and volume. Imaginative comparison of what you make with what you buy and sell often suggests byproduct streams as alternative materials. Cost savings are often a consequence. Dedicated, persistent effort is a routine requirement. It helps to remember Ralph Waldo Emerson's remark "nothing great is achieved without enthusiasm." Early in this century the American Meatpacking Industry developed a reputation for their effective use of all parts of a pig. It is widely reported that they use all the parts except the squeal. We're not down to the squeal yet, but were listening for it!

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DESIGN FOR THE ENTIRE LIFE CYCLE: A NEW PARADIGM?

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"The natural sciences are concerned with how things are. . . Design, on the other hand, is concerned with how things ought to be, with devising artifacts to attain goals." Simon, H.A., The Sciences of the Artificial, MIT Press, 1969. (1)

"Design should not merely meet environmental regulations; environmental elegance should be part of the culture of engineering education and practice. Selection and design of manufacturing processes and products* should incorporate environmental constraints and objectives at the outset, along with thermodynamic and economic factors".

National Academy of Engineering, 1989. (2)
*Overby's underlining

ABSTRACT

This paper explores the idea of design for the entire life cycle -- including the disposal phase of a product's life. It is postulated that there are environmental, consumer, legislative, competitiveness issues, and a changing world in the technology of design -- such that we need to look at things in a new light (a new paradigm) relative to the way that we create and get rid of the material "things" of life. This paper briefly touches on each of the above ideas as a path to get to asking: What might be done in engineering education and in engineering practice so that design considerations for disposal get factored into the design process at the very beginning of that process? More broadly we might ask, how can we get to the point where "environmental elegance" becomes an integral part of the culture of engineering education and practice. The paper outlines a few ideas for some soon to begin research along these lines at the School of Engineering, Grand Valley State University (GVSU), Grand Rapids, Michigan. This research is to be funded through the Michigan Quality of Life Bond Fund, Michigan Department of Natural Resources.

Much credit must be given to Dean Kindschi (GVSU) for his role in rekindling my dormant interest in this challenging area of concern, and for his considerable effort in getting us to this point. Credit is also due to Assistant Dean Larson, and to Shelley Padnos for their major contributions, and to colleagues, Shirley Fleischmann, and Paul Johnson for their willingness to professionally join this undertaking.

The views here expressed are the views of the author and do not reflect those of any other person or institution.

THIS IS AN EXTREMELY ABBREVIATED VERSION OF A PAPER WITH THE SAME TITLE THAT WILL BE GIVEN TO THE "DESIGN ENGINEERING DIVISION MEETING" AT THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION (ASEE) ANNUAL CONFERENCE IN TORONTO, CANADA ON JUNE 25TH, 1990. READERS OF THIS MATERIAL WHO WOULD LIKE TO SEE THE ENTIRE ORIGINAL PAPER SHOULD SEE THE 1990 ASEE ANNUAL CONFERENCE PROCEEDINGS, PAGES 552 -- 563, OR CONTACT THE AUTHOR AT THE ADDRESS GIVEN ON THE TITLE PAGE.

INTRODUCTION

People all over this land are becoming concerned with the continuously growing waste stream resulting from the affluent life styles lived by the majority of us, and at the negative environmental impacts that result from disposing of these wastes. These concerns, along with a decline in low cost disposal options are causing people to ask if it might be possible to gain some control over these problems by "minimizing the waste stream at its source". Among the many possibilities for "source reduction" are ideas about designing products with concerns for "disposal" considered at the very beginning of the design process. If we include "design criteria" for disposability in our product designs, the resulting products might become more easily recyclable as products, or to basic materials. They might become products that have much less waste to be "disposed of". Or, if their disposal problem appeared to be overwhelming, then they might never "see the light of day" as things for our consumption. In short, we might call them "earth friendly products". Following is an exploration of some of these issues in the context of "design for the entire life cycle".

Engineering design textbooks sometimes mention the need to be concerned, at the beginning of the design process, with the entire life cycle of the product or system, including its disposal. For those authors who do mention it (and many do not), other than a few words or a brief paragraph or two early in the book, nothing more is heard of the "disposal phase" for the rest of the book.

This paper, in part, arises out of some of my past work in resource conservation, solid waste, and related environmental issue areas. (3), (4), (5), (6). I intend the paper as an "exploratory vehicle" with which to provoke responses from and for interaction with (A) designers and creators of products and systems, (B) engineering educators, and (C) "interested others" --on the idea of "Design for the Entire Life Cycle: My specific focus will be on the neglected "disposal phase" of the cycle.

The words "A New Paradigm", with a question mark, appears in the title because it seems to me that several things are "working" out there in the world of legislative affairs, environmental concern, international competition, and with the "technology of design" itself, such that engineers and other creators of new products and systems, in the future, may well find their concepts of "design" stretched to include the entire life cycle of their creations (including disposal) much more often than has been the case in the past. If this is true, then we might well think of it as a "new paradigm", a new way of seeing things, a new model or pattern for organizing ourselves in the production of the goods for our affluent life styles. If we in the developed world can do this, we may even be able to present the developing countries of the world (with their masses of drooling prospective consumers) with a new model so that they might also enjoy some of the "goodies" without completely sacking the world environment.

OBJECTIVES AND LIMITS OF THE ORIGINAL PAPER

In the original paper I (A) first defined and briefly elaborated on the concept of "design for the entire life cycle", pointing out how very important the designer is in determining the "downstream" consequences of his or her creations -- life cycle costs etc. (B) discussed some of the flux of things happening "out there" by touching on (a) some contemporary environmental, (b) international competitiveness, and (c) design technology issues all of which I think might in some ways be relevant to the topic; (C) highlighted the focus of our proposed research at GVSU, and finally; (D) raised some questions as to what we might do in the education of engineers so that "design criteria for disposability", "design criteria for recyclability", "design criteria for waste reduction and minimization" and more broadly, so that "environmental design requirements" might become a more important part of ALL engineering curricula--not just the specialized curricula for so-called environmental engineers. The original paper did not concern itself with public policy measures for stimulating "design for the entire life cycle".

In order to meet proceedings publication deadlines, and to conform to space limitations, I have excised most of the original paper, leaving only the outline of our proposed research at Grand Valley State University, and the questions as to what we might do in the education of engineers for "environmental elegance". The following original paper headings have been left out of this version: "Design for the entire life cycle"; "Environmental concerns and adaptations"; Professional concerns for the environment"; "Industrial concerns for the environment"; Grassroots concerns for the environment"; "Spiritual concerns for the environment"; "Governmental concerns for the environment"; "Changes in the field of design"; "Legislatively driven design change"; "Competitiveness driven design change"; "Quality function deployment"; "Taguchi philosophy -- quality is the loss a product causes to society after being shipped..."; "Design principles"; "Expert systems in design"; "Design data bases and information systems".

HIGHLIGHTS OF OUR PROPOSED GVSU RESEARCH*

We propose to carry out the following tasks and activities in our research at Grand Valley State University on this topic. (9)

(A) Identify and build a database for several contemporary products that create environmental and/or recycling problems at the time of their disposal.

(B) Select a sample from this database and carry out a design assessment for these products so as to identify design changes that, had they been made, could have improved the environmental impact and or recyclability -- design changes that could have made the products more "earth friendly".

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*I have agreed to be Project Director for this research.

(C) In parallel with (A) and (B) above, we will be doing research on ways, short of public policy measures, by which it might be possible to make it easier for engineers and others responsible for design to include design considerations for disposability at the very beginning of the design process. We will explore many of the things presently happening in the field of design in an attempt to identify how it might be possible to use some dimensions of this present "dynamism in design" to help "stretch" the designer's perspective to include more of the life cycle of the product. Preliminary ideas along these lines have been presented in this paper. (the original paper) Included in these explorations will be concepts of "expert systems", "quality function deployment" (QFD), "Taguchi ideas", "design engineering databases", "concurrent or simultaneous engineering", and other aspects yet to be identified as the research progresses.

(D) In parallel with (A) through (C) above, we will be hosting a series of seminars with visiting experts on topics related to "design for recyclability", "design for the entire life cycle", "design of earth friendly, clean, or green products", "design itself" and selected concepts from our research in (C) above. These seminars will be designed to both inform us, and to provide a forum for discussion with practicing engineers, academicians, consumers, environmentalists, managers and other interested persons. The seminars and individual interviews with the "experts" will be video taped for possible later use as educational material.

(E) Drawing on all of the above, we intend to prepare academic materials for two different groups of engineering students -- one at the freshman level, and one for students at the senior design "capstone" course level. We presently envisage these materials as having at least two dimensions --a set of readings that relate to (a) environment and engineering, technology, design etc., and (b) a set of case studies and/or design projects that will serve to educate with respect to "environmental design concerns" as well as "engineering functional" and "economic" concerns in engineering design.

(F) Finally, we intend to write and present papers at appropriate technical and other meetings on various dimensions of this research so as to further its dissemination as broadly as possible in engineering education and engineering practice.

IMPLICATIONS FOR ENGINEERING EDUCATION

I began this paper with the following quote from a new National Academy of Engineering publication.

"Design should not merely meet environmental regulations; environmental elegance should be part of the culture of engineering education and practice. Selection and design of manufacturing processes and products should incorporate environmental constraints and objectives at the outset, along with thermodynamic and economic factors." (2)

I now end it with the question -- How do we translate the "shoulds" in this quote into reality in engineering education so that environmental elegance, including design for the entire life cycle, does in fact become a part of the culture of engineering education and practice?

Some think that this will happen naturally as legislation finds ways to connect the producer with his or her products for their entire life cycle. But, can we not see some possibilities outside of governmental action, that might help to make it easier for engineers to factor "environmental requirements" as well as "functional requirements", and "economic requirements" into the design process at its very beginning?

If public environmental concerns continue to grow, might it become possible for the Acreditation Board for Engineering and Technology (ABET) to find a way to "require" engineering curricula for ALL engineering disciplines to reflect "environmental elegance" in their curricula? Perhaps this is not such a wild idea. Recently we see discussion about requiring a certain course for all engineering students so that our engineering graduates can be more effective and productive in their work, and thus help this nation get back into the ballgame in international competition. I am speaking of proposals to require an appropriate kind of "statistics--experimental design" course for all engineering students. (43) Incidentally, some of the driving function for the above discussion partially arises from the popularization of Taguchi's ideas of experimental design as a very important engineering data gathering and decision making tool.

Might not the "enlightened self interest" expressed by various companies and industrial trade associations in this era of "new paradigms" present opportunities for us to demonstrate to engineering students the fact of "environmental elegance" in places where they will work? (23) (19)

Hopefully, the development of "readings" and "case studies" and/or "design projects" such as proposed as one of our research outcomes, might have some small continuous improvement impact in the creation of "environmental elegance" as an appropriate engineering "mind set".

If an "expert system" were developed with paths that required consideration of the disposal phase (or other environmental concerns) at the beginning of the design process -- might not the use of this "expert system" as a tutorial device to train fledgling engineers in the design process, help make a small contribution toward "environmental elegance" as an appropriate engineering attitude?

If an engineering design database were augmented with health and environmental impact information in relationship to various materials and processes choices to be made by the designer, might this be of some help in achieving "environmental elegance" as a stronger dimension of engineering education and practice? --- What suggestions have you?

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WASTE REDUCTION AT A PRINTED CIRCUIT BOARD MANUFACTURING FACILITY USING MODIFIED RINSING TECHNOLOGIES

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ABSTRACT

The Minnesota Technical Assistance Program (MnTAP) and the U.S. EPA began this program to assess waste reduction achievable for rinses on two processes at Micom, Inc., a printed circuit board manufacturer. Baseline measurements for wastewater volume and copper concentration, the waste parameters of interest, were taken along with measurements for drag out and rinsing effectiveness. Candidate rinsing modifications include: slowing the rate of withdrawal, increasing the drain time, reducing the rinse flow with restrictors, and controlling the rinse flow with conductivity meters. The most promising modifications will be implemented. Follow-up sampling will be performed to evaluate the effect of rinsing modifications on wastewater volume and copper concentrations. Rinsing effectiveness and drag out were assessed in baseline sampling and will be assessed following each modification.

This study is being conducted as part of the U.S. EPA's Waste Reduction Innovative Technology Evaluation (WRITE) Program, which was funded by a cooperative agreement between the EPA and the University of Minnesota, Minnesota Technical Assistance Program (MnTAP).*

*The Minnesota Technical Assistance Program (MnTAP) is supported with a grant from the Minnesota Office of Waste Management (OWM) to the University of Minnesota, School of Public Health

INTRODUCTION

The Minnesota Technical Assistance Program (MnTAP) has allocated a considerable amount of its resources to providing waste reduction assistance to the metal finishing industry in Minnesota over the last five years under the support of the Minnesota Office of Waste Management (OWM). More recently, MnTAP has been working cooperatively with the U.S. EPA Risk Reduction Engineering Laboratory under the Waste Reduction Innovative Technology Evaluation (WRITE) Program to assist metal finishing companies in achieving waste reduction by modifying rinsing techniques.

A number of large electronics and computer manufacturing firms are based or located in Minnesota. As a result, approximately 200 small and medium-sized job shops, printed circuit board shops, and other electroplating/metal finishing operations exist in Minnesota to support the larger companies. The metal-containing sludges, solutions, and rinsewaters from these shops comprise 19 percent of the hazardous waste stream generated in Minnesota.

Solicitation of metal plating companies for participation in the WRITE Program began in early 1989 through newsletter articles, metal finishing association presentations, and by direct mailings. Approximately 20 companies responded with interest in evaluating source reduction opportunities via rinsing modifications. Once the WRITE engineer began work in mid-August 1989, site visits were conducted to assess each company's interest and applicability to the project. A total of thirteen shops were visited, six printed circuit board shops and seven job shops, primarily rack and barrel electroplating shops. Companies are evaluated for inclusion in the WRITE Program on the basis of a number of criteria which include potential for pollution prevention, willingness to make modifications, willingness to share information, production variability, and a measurable quantity/concentration of contaminant to be reduced.

PROJECT OVERVIEW

The overall objective of the Minnesota/EPA WRITE Program is to implement and document source reduction practices to reduce waste generation by modifying rinsing techniques as part of the plating process. However, a number of more specific objectives exist. The two most effective methods for reducing wastes as a part of the rinsing process are reducing dragout or carryover of metals from the plating bath and practicing water conservation methods. This project focuses on evaluating rinsing modifications on a single plating line. These modifications, once evaluated, could then be transferred to other lines within the facility. The impact on downstream treatment or recovery technologies will also be examined, as it is believed that the combination of reduced drag out and reduced water use should reduce treatment needs and associated costs.

The first WRITE company, Micom Inc., was selected largely because of their willingness to make changes and because of their relatively stable production. Micom is a medium-sized job shop in New Brighton, Minnesota, employing approximately 240 people. The company manufactures printed circuit boards under a number of military and other contracts. A production day consists of two eight-hour shifts with a current work load of 1,000-1,200 square feet of panel per day. The WRITE project is concentrating on the counter current rinses which follow the micro-etch bath, and the counter current rinses which follow the electroless copper bath. The waste water from these rinses is currently being treated by ion exchange for copper recovery.

MnTAP is obtaining data from these lines both before and after rinsing modifications are made. A baseline of waste generation has been established by measuring rinse flows, copper concentration in the rinses, and other parameters such as process solution copper concentrations, drain time, carry over of process solution (dragout), and production throughput. The same information will be collected after each modification. In this way, a baseline of rinsing effectiveness can be established by measuring residual copper concentration on the printed circuit boards after rinsing. This baseline of rinsing effectiveness can be used for comparison following each rinsing modification to ensure that product quality is not being interfered with. Armed with this information, the company can be convinced that the rinsing modifications are worth pursuing and will not compromise product quality.

MICOM PROJECT PURPOSES AND OBJECTIVES

The two major objectives of the Micom project are to reduce the copper discharged in the rinsewaters from the sensitize line, and to reduce rinsewater volumes in that same line. In the case of reducing copper discharge, at least three benefits are possible. If copper discharge is reduced by capturing process solution before rinsing, raw material costs may be reduced, since the need for chemical additions could be reduced by returning process solution to the bath. Treatment costs may also be reduced, especially in the case of Micom, which uses ion exchange to capture copper from the rinsewaters. In addition, reducing copper discharge by capturing process solution can also reduce the amount of water needed for rinsing, since less residue requiring dilution (rinsing) will be present.

Reducing rinsewater volumes will be possible both because of the previously mentioned reduction of residue needing rinsing, and also because it may be possible to improve rinsing efficiency. Improving rinsing efficiency, which implies using less water to achieve the same rinsing effect, can have at least two benefits. Using less water will decrease water and sewer charges, especially important at Micom where incoming water must be softened, at additional cost, before use on the sensitize line. Decreased rinsewater volumes may also reduce treatment costs, both by improving the efficiency with which the ion exchange system at Micom is able to remove copper from rinsewater, and also by reducing the amount of water which must pass the resin beds.

For the Micom project, not only is the work focused on one process line, but also further narrowed to focus on two process steps within that line, the micro-etch and the electroless copper plating solution (explained in more detail in the next section). The reason for that focus was first a matter of economics, since only a certain amount of time and money can be spent on evaluation in any one shop. Another reason is that these two processes are the most concentrated copper sources on the process line. The focus is also part of a larger philosophy, one which MnTAP calls "planting seeds." The hope is that if rinsing process modifications are demonstrated to be successful in one location in a plating operation, plant management will be more likely to attempt similar modifications on that process line, or even on other process lines. Rather than attempting plant-wide modifications, or changes applied to large, aggregated waste streams, a staged approach is not only more manageable, but may be more accurate in the assessment of costs, product quality, and other advantages.

Besides the two major objectives of reducing copper discharge and water use, MnTAP hopes to develop and test a procedure for evaluating and modifying rinsing processes which will be transferable to and useful with other operations. This procedure would address such imperatives as protecting product quality while simultaneously modifying the production process, evaluating the impact of modifications on production throughput, and providing a "rule-of-thumb" for such decisions as number of samples required for evaluation. MnTAP believes this procedure to be a very important transferable product of the project.

MICOM PLANT DETAILS

Micom manufactures double-sided and multilayered printed circuit boards. Printed circuit boards are produced by depositing and etching metal from a fiberglass sheet (board). The steps in this process include: cutting the boards to size, coating the boards with a photosensitive material (resist), developing the resist, drilling holes, deburring, cleaning, etching, plating the inside of the holes (using an electroless plating process), plating the board, and inspecting at many points along the way. Water rinses follow many of these steps.

All printed circuit boards at Micom pass through the sensitize line (Figure 1). This line is used to plate copper onto the inside of the circuit board holes and is composed of micro-etch, activator, accelerator, electroless copper and rinse tanks. Micom is interested in changes to the micro-etch and electroless copper plating and rinsing processes as these are significant contributors of copper to their wastewater treatment system (currently ion exchange). The copper bearing countercurrent rinses are made up of softened water with restricted flow of 3 gpm per set of tanks. These water flows are piped to the copper ion exchange system and then sewered.

The printed circuit boards enter the line in racks holding 24 boards. The boards range in sizes up to 18 inches by 24 inches. The racks are 34 inches by 19.5 inches by 13 inches and are transported by a hoist from tank

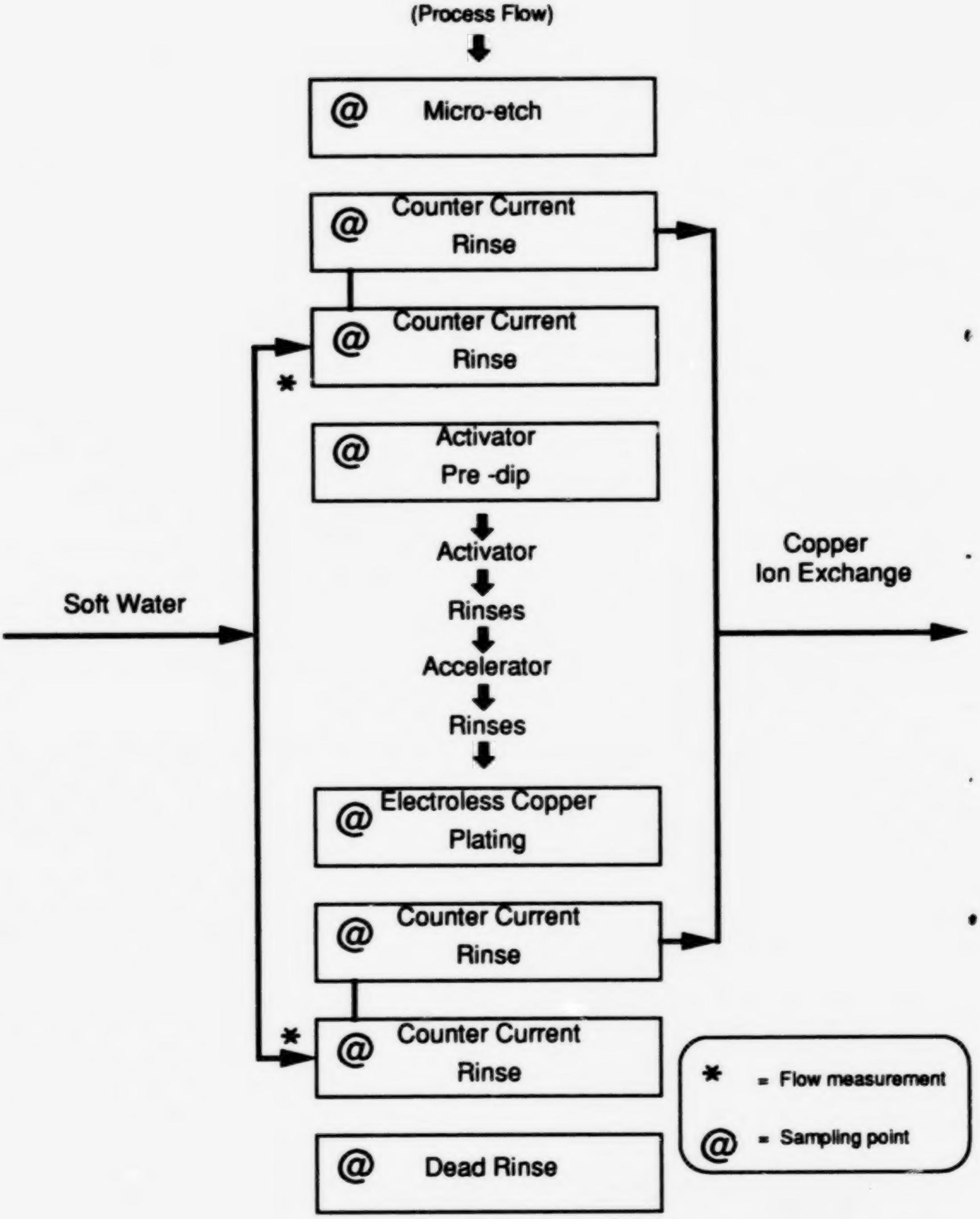

Figure 1 Micom Sensitize Line

to tank. The operator controls the hoist and allows the rack to drain 3-5 seconds before proceeding to the next tank. The approximate residence time in the micro-etch bath is 75 seconds, the electroless copper bath is 30 minutes, and each rinse bath is 2 to 3 minutes. The electroless copper plating is the rate determining step for production throughput.

MnTAP intends to maintain or improve the current rinsing effectiveness. This is monitored by checking the amount of copper build-up in the non-flowing process tank which follows the countercurrent rinses. An objective of the company is to maintain the current production throughput rate.

GENERAL RINSING MODIFICATIONS

Although there are numerous modifications to rinsing operations which can reduce rinsewater volumes while preserving rinsing effectiveness, a number of these techniques are particularly attractive at an installation such as Micom's. These techniques can be broken down into three categories: procedural, systems, and controls.

Procedural techniques in rinsing refer to work flow, operator routines, and work practices. Several procedures can be used to reduce dragout in a plating shop:

> Improved work flow in a plating shop refers to the most direct route a part can take from the time a part enters the shop to the time a part leaves a shop.
>
> Proper racking of parts affects the way in which solution drains off the part.
>
> Increased hang times allow solutions to drip back into the process tank, thus conserving process solutions and reducing dragout.

A number of other methods exist which can be practiced by operators to help reduce dragout:

> Slower withdrawal rate of parts from the plating tank or rinse enhances return of solution to the process tank
>
> Longer rinse times allow for better rinsing
>
> Use of wetting agents reduces surface tension of process solution
>
> Operating the plating bath as hot as possible decreases solution viscosity
>
> Minimizing the concentration of dissolved materials in the plating bath minimizes the concentration of metal in the dragout

Systems which facilitate improved rinsing techniques involve modifications to the rinsing tank design or the set-up itself. Proper use of the following systems can result in reduced dragout of process solution into the rinse tanks, concentration of solutions for reuse, and generally more efficient rinsing.

Dragout tanks function not only to save water, but also as a basic component of the rinse line to allow for chemical recovery and return to the process tank.

Spray rinsing of parts can be an effective rinse technique because even with a small volume of water, the contaminant on the surface of the part can be diluted enough to make the rinsing effective.

Agitation is more commonly used in rinse systems to increase the efficiency of the rinses so that water use can be minimized. Two primary types of agitation are used: air agitation (sparging) and mechanical agitation.

Countercurrent rinsing refers to a system in which clean water enters the last rinse in a line (cleanest) and works its way through each of the first rinses (dirtiest) in the system. Each additional rinse results in an approximately eight to ten-fold reduction in water use.

A number of control techniques may be used in rinsing systems to reduce water usage. These are best implemented after earlier modifications have been implemented, and water needs to be reduced.

Conductivity controllers measure the amount of dissolved solids in the rinse. When the level reaches a preset minimum, it shuts off a valve, interrupting the continuous fresh water feed to the rinse. When the concentration of dissolved solids reaches the maximum allowable level, the cell opens the valve.

Flow regulators are another water saving device which can be used to control the fresh water feed within a narrow range. These devices eliminate the need to reset the flow each time the valve is closed.

SPECIFIC MODIFICATIONS FOR MICOM

At Micom, the process of selecting implementable rinsing process modifications has focused on: available equipment, impact of a modification on process solutions, product quality, and effect on throughput. Production objectives (quality and throughput) are paramount, as might be expected. As it happens, the project is structured so that these objectives are implicitly considered in decision making, so the question actually becomes one of implementation.

The first option that will be implemented at Micom is extended withdrawal rate from the process solutions, accomplished by slowing the motor on the hoist used for raising, lowering and transporting racks of circuit boards. The literature suggests that this option has the largest potential for reduction (up to 60%) of dragout, and also combines the effects of solution viscosity aiding solution removal and extended drain time (since the parts are necessarily drained longer while being withdrawn more slowly). In both cases, the effect on process solutions is an important consideration. Retaining process solution which was formally lost to dragout often means the solutions must be replaced more often. MnTAP believes that managing the concentrated waste stream resulting from bath dumps is preferable to managing diluted rinsewaters. Opportunities for metals recovery are improved if the wastestream is concentrated. The treatment of a dilute wastestream generates more sludge than a concentrated wastestream.

After reducing the amount of copper reaching the rinsewater by extending withdrawal rates, rinsewater use will be reduced by installing "needle" valves and throttling the flow. When the baseline concentration (measure of rinsing effectiveness) is again reached, the volume and/or distribution of air in the currently installed air agitation system will be modified in an attempt to increase rinsing efficiency and thereby potentially further reduce water needs. While the literature does not indicate optimal air volumes or distributor designs, visual inspection of Micom's rinse system reveals the air agitation is "gentle", rather than "vigorous." Vigorous agitation has the potential to significantly improve the dynamics of dilution which lead to efficient rinsing.

BASELINE MEASUREMENT METHODS

To properly evaluate the modifications of the rinsing process, MnTAP established a baseline for copper dragout, water use, and rinsing effectiveness for the Micom project.

To measure the dragout from the process solution, the incoming softened water flow to the rinse tanks was temporarily shut off. The first and second rinse tanks were sampled (Figure 1) before and after a known quantity of printed circuit boards were rinsed (one or two racks of 24 boards). The process bath solution was also sampled immediately after a rack of boards was removed. The change in the copper concentration in the rinses was analytically determined by atomic absorption. The area of the printed circuit boards, which were rinsed during the sample period, was calculated to enable a comparison based on square footage of production. The dragout can be calculated by dividing the change in copper concentration in the rinses by the concentration of the process solution and then normalizing the result by dividing by the surface area of the boards processed.

$$\text{Dragout} = \frac{(\text{change in copper concentration in rinses}) \times (\text{volume of rinses})}{(\text{copper concentration in process solution}) \times (\text{surface area of boards})} \quad [\text{ml/sq. ft.}]$$

The water flow rate was calculated by measuring the time it takes to fill a five gallon container from the rinse tank discharge. The rinsewater flow rate can be expressed in gallons per minute. Rinsing effectiveness was determined by measuring the residual quantity of copper on the printed circuit boards after they have been rinsed. This was done by analyzing for the build up of copper in a non-flowing tank immediately following the counter current rinses. The build up was measured over the period of a shift by taking two samples, one at the beginning and one at the end of the shift.

RESULTS OF BASELINE CALCULATIONS

One hundred thirty-six samples were analyzed to determine the volume of dragout from the micro-etch and the electroless copper baths for twelve pairs of racks over a two week period.

Dragout from the micro-etch - 10.8 ml/sq ft
Standard deviation - 3.5
Range - 7.6 to 14.5

Dragout from the electroless copper - 6.1 ml/sq ft
Standard deviation - 1.3
Range - 4.7 to 8.7

The flow rates of the rinses following the micro-etch and electroless copper baths were sampled twelve times over two days.

Flow rate from micro-etch - 2.6 gallons/minute
Standard deviation - .04
Range - 2.5 - 2.7

Flow rate from electroless copper rinse - 3.3 gallons/minute
Standard deviation - .05
Range - 3.2 - 3.3

Forty samples were analyzed to determine the rinsing effectiveness. The build-up following the micro-etch rinses was less than 10 mg/l per shift. The build-up following the electroless copper rinse was less than 0.1 mg/l per shift.

MnTAP is currently in the process of implementing the first modifications, slowing the rate of withdrawal and extending the drain time. The procedure is to determine the effect these modifications have on copper dragout and rinsing effectiveness, and then continue with other/additional modifications such as lowering the rinsewater flow rate. The modifications will be evaluated and the results presented to the management at Micom. Micom will decide which modifications will be permanently put into place. All modifications will be tested to ensure rinsing which is at least as effective as what is currently in place.

SUMMARY

The MnTAP/EPA WRITE project at Micom, Inc. has been designed to evaluate rinsing process modifications which may reduce copper concentration in rinsewater and reduce water use. A baseline has been established for flow rates and drag out volumes of process solution. The plating process has proven to be inherently difficult to characterize, primarily because of variability due to operators, solution concentrations, and production change. Future work includes implementing at least two modifications, with goals of 30% reduction in copper loading and 20% reduction in water use, while maintaining production quality and throughput.

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Keynote Address
International Conference on Pollution Prevention:
Clean Technologies and Clean Products

Omni Shoreham Hotel, Washington, DC
June 11, 1990

DEPARTMENT OF DEFENSE POLLUTION PREVENTION INITIATIVES

by
William H. Parker, III, P.E.
Deputy Assistant Secretary of Defense (Environment)

Introduction

Thank you and good morning. We are very pleased, as part of DoD, to be here and to contribute to this important conference. I wish you well over the next three days.

I am especially pleased to be here because:

1. DoD is an international organization, and we do have concerns that go much beyond the boundaries of the United States, and
2. This is the last major speech that I will be giving at DoD, because I am leaving to go back into the private sector at the end of this month.

It just so happens that my pet program is pollution prevention. This is a terrific way for me to, one last time, talk about the program that I think has the most potential and makes the most sense for all of us to comply with.

There is a difficulty in coming up with terms, so I would like to define mine before we get started. First of all is "waste treatment" or "end of pipe." Second is "hazardous waste minimization," which I refer to as the "ex poste" problem, or big problems that already exist that have big payoffs if there are solutions. The third term is "pollution prevention." I refer to this as "ex ante." It covers all areas. It is to proactively prevent pollution. I believe at DoD we have made outstanding progress in dealing with all of these problems and in preventing future problems. I truly do believe that we are learning from the past.

Topics that I am going to cover with you this morning in order to give you an idea of how we are dealing with our problems are:

1. DoD environmental policy.
2. DoD operations and pollution potential.
3. Environmental leadership program.
4. Hazardous waste minimization efforts.
5. Pollution prevention initiatives.

During the next three days our experts will be covering with you how they implement many of the programs that I am talking about with you this morning. I won't get into the vast details of these programs because of the fact that they can cover it much better than I can in separate sessions.

DoD Policy

First, I would like to cover DoD policy. As I talk this morning I am going to focus primarily on the policy that relates to what we call CONUS (Continental United States), including all fifty states and the U.S. territories.

First of all, our policy states that we will comply with all applicable Federal, State and local laws and regulations. Secondly, we require analyses of environmental consequences of proposed actions. In other words, we follow NEPA. Third, our policy requires the minimization of environmental impacts as we accomplish our mission. Of course, our mission is national defense and even though we are seeing a so-called peace dividend, we still have the responsibility of national defense and have to work our environmental programs into the basic mission. I will talk more about that in just a few moments.

Next, our policy requires that we provide good stewardship of natural and cultural resources. Finally we require that the military cooperate fully and openly with environmental regulatory agencies. This is a major challenge for us since we have 900 major installations in the fifty states and territories. It is very tough for us to do this under a centralized program dealing with the different nuances of the various laws of the different states, EPA regions, and municipalities.

DoD Operations and Pollution Potential

To do this brings me to the second topic, which is DoD operations and pollution potential. We have approximately five million military and civilian people in the Active Service, Reserve, and National Guard. Of course, that number is going down as we reduce our military obligations, but still at this time it is about five million people. World-wide we have major installations totalling over 1,200 and probably two or three times this in minor installations. Here in the United States we are stewards for 25 million acres of land, equal to the state of Tennessee. This is one of the key issues people sometimes don't think about - that we are responsible for so much land. We do have the responsibility for biodiversity on this land. We do have people living and working on the installations whose health and safety we are concerned about.

Our installations are diverse in nature. We have airports, seaports, industrial operations, laboratories, training ranges, and so forth. Also, our installations are small cities with housing, business, industry, hospitals, recreation and just about anything else that you can think of in communities. The pollution potential is very large and diverse within DoD. We have municipal and industrial waste, both solid waste and hazardous waste, as well as liquid waste, and air emissions from mobile and stationary sources. You might be surprised to know that DoD is the country's largest user of petroleum products. Worldwide, we use approximately 350 thousand barrels per day and our consumption here in the U.S. is equal to somewhere between one and two percent of national daily use. We have point and non-point pollution from troop training and equipment maintenance and repair. In short, we face the same set of problems that EPA does. Also like EPA, we have to prioritize and look at how to best accomplish our environmental mission with the limitations within which we have to work.

DoD Environmental Leadership Program

This brings me to my third topic, which is DoD's Environmental Leadership Program . First of all, our direction comes from President Bush and from the Secretary of Defense - Secretary Cheney. On October 10, 1989, the Secretary put out a memorandum on environmental policy. I would like to share a couple of paragraphs from that memorandum with you and then talk quickly about several of the points in this memo. The Secretary stated "This Administration wants the United States to be the world leader in addressing environmental problems, and I want the Department of Defense to be the Federal leader in agency environmental compliance and protection." It goes on to lay out the program and concludes with "We must be fully committed to do our part to meet the worldwide environmental challenge, and I know I can count on your support to ensure that we are successful in that effort."

His environmental memorandum laid out several points. As I mentioned, his first paragraph says that we are to become the Federal agency leader. Here he means within the regulated community. The second point in his memorandum is that environmental compliance must become a command priority. Third, is to integrate and budget environmental considerations.

This is the big "M" word - Money. Money drives all Federal programs. It drives everything, and in order for us to be effective in the environment, we have to budget, we have to get the money to do the work. The next point he made is to communicate problems and successes. This is the responsibility of everyone in DoD, and it is a requirement of good leadership. Finally, the payoff. There has to be outside recognition of our efforts because this is the surest way to maintain access to air, land, and water for defense preparedness. Therefore, we view being a good environmental citizen as part of our mission.

From the Secretary's memorandum, we have prepared what we call an Environmental Leadership Program which has six goals. I will briefly go through those, and then I will hit on several of the subgoals as they apply to pollution prevention.

1. First of all is sustainable compliance, perhaps a new term for some of us. It is a proactive approach. The military has a saying "If it ain't broke, don't fix it." With sustainable compliance, what we are saying is "Use it, look at it, and if you think it's going to break, fix it before it is broken."
2. Second is obtaining the resources - not only the "M" word (Money), but also people, and provide those people with the training that is needed at each and every level to do their job.
3. Third is communication, both internally and externally. First of all, the good news, or if you will, our bank deposits. Secondly, tell the bad news because we can't hide it. This is our bank withdrawals. We have to have many more deposits than we do withdrawals in order to show that we are serious about the environment.
4. Next is environmental planning and awareness under systems acquisition. First of all, we want to try to keep hazardous materials out of systems. Secondly, we want to look at how those systems are going to operate and make sure that wherever possible they do not affect the environment, and if there is an effect, that the effect is minimized.
5. Next is pollution prevention through TQM (total quality management) and life cycle cost analysis, which to me as an engineer, is nothing but plain good business.
6. Finally, is to develop reliable measures of progress and feedback systems. The public demands nothing less than that we be able to quantify what kind of progress we are making. In DoD, we have gotten past the stage where we are using catchy slogans to motivate people without any way to quantify those results.

Now I want to touch briefly on several subissues of the environmental leadership program which I think apply to pollution prevention:

1. First of all is cultural change. Number one is to publish the Hazardous Material Pollution Prevention Directive, which has already been done. Then is to integrate environmental protection and compliance into DoD's mission - that is, change the culture.

2. Second is compliance with environmental laws. Here one of the things that we said is "Make commanders accountable for making it happen. Audit requirements and track performance."

3. Under people, we said "More environmental staff, multi-disciplined," because we also concur that solving environmental problems is a multi-disciplinary problem. The second point under people is better training in environmental programs. We maintain that everyone in DoD who goes into any training program should have some unit of environmental training, and a unit that helps him do his job better. Third is clear accountability for DoD employees and their commanders. We expect to hold people accountable, we expect them to know it, and we expect them to perform it.

4. Next is on the budgets. One is to develop a master plan and program funds to match. Second is priorities for all environmental funding on a worst-first basis.

5. Training. We talk about integrating applicable environmental training in all our military and civilian training programs. I mentioned that before and obviously there is some overlap in many of these programs.

6. Last, under regulatory relations - establish a partnership with EPA and the states in environmental master planning and also proactively solicit state involvement in all our programs. In order to do this, we have entered into preparation of strategic plans for the environment. This fall we have a DoD Environmental Forum in which we will solicit external ideas, and we will communicate. The output of this will be used as some of the input to our Strategic Plan. We are required by Congress to submit a report on our long-range goals by November of 1991. All of these things together represent the start of what we call our D&EI - our Defense and Environmental Initiative. Also, you may have read about the Defense Management Review, which has been undertaken by the Secretary. Under that, we are consolidating environmental directives, updating all our directives that apply to all environmental media.

DoD HazWaste Min & Pollution Prevention Efforts

One of those media is the fourth item that I am going to cover this morning - DoD's hazardous waste minimization and pollution prevention initiatives. In our 1985 Projects of Excellence effort, we evaluated DoD industrial process changes for hazardous waste minimization successes and failures. We identified major sources of hazardous waste in our industrial activities, which, by the way, represent about 80 percent of the production of hazardous waste at DoD. This includes machining, solvent cleaning, plating, painting, and removal of paints and coatings. We came up with factors of success, especially motivating production people and making evolutionary, rather than revolutionary, changes - changes which are elegant in their simplicity. Or, in other words, just plain good innovation.

To date we have funded over $200 million in HazWaste Min projects from the Defense Environmental Restoration Account and from the Services budgets. We have prepared reports to Congress on our progress. We have put out a DoD pollution prevention directive. We have also entered into an extension of an agreement on Chesapeake Bay with the EPA, signed as part of Earth Day by Secretary Cheney and Bill Reilly. In that, one of the initiatives is a multi-media, model community, pollution prevention, demonstration project on one of our bases.

We are working on the reduction of CFCs and halons through a DoD directive. I think that this is also a model of how EPA, DoD, and industry are working together to phase out the use of CFCs and halons. For instance, halons are very important to us. They are used, because they are non-toxic, as fire suppressants in our jets, on our ships, in our tanks, and other equipment. You can see how important it is for us to find suitable substitutes for these materials.

We are developing a better hazardous waste tracking and indexing system. I would like to give credit to the military Components, the Joint Logistical Commanders, the Joint Depot Maintenance Analysis Group, and the Joint Depot Environmental Panel for the work they are doing in pollution prevention and hazardous waste minimization. We are working on a recycling program. We have one that we are just kicking off, as a matter of fact, at the Pentagon itself. Another major program is our Chemical Demilitarization program. We are just starting up Johnson Island for the destruction of many of these weapons. And last, it is fitting to point to CERCLA and our Installation Restoration Program, where the remedial action preference is for treatment to permanently and significantly reduce the volume, toxicity or mobility of hazardous substances. We are spending somewhere between $600 and $800 million per year on this particular effort.

It wouldn't be fitting to end my remarks without quoting from one great American group ... from the "DENNIS THE MENACE"® comic strip. Several years ago, a "DENNIS THE MENACE"® public service poster defined progress as follows: "Progress is when everyone pushes in the same direction." DoD's environmental policies and pollution prevention initiatives are intended to get all five million people at all 1,200 bases pushing together for a better environment.

["DENNIS THE MENACE"® used by permission of
Hank Ketcham © by North America Syndicate]

It has been said that there is a natural bond between those who work to protect our Nation and those who work to protect our environment. In order to do this we need experienced engineers and technicians to design and implement these programs. I am very concerned about the potential shortages in this area, so we have got to work smarter. There is a need for cultural change, because many of these things require cultural solutions. I believe that pollution prevention can help conserve shrinking DoD resources.

Conclusion

This morning I have briefly talked to you about our environmental policies, our operations and pollution potential, our leadership program, our HazWaste Min efforts, and our pollution prevention initiatives. Since this is my last major speech, I would like to look into my crystal ball for just one second and give you some observations about the key DoD issues for the 1990s.

First of all, I do believe that hazardous waste minimization and pollution prevention have got to be one of the four issues DoD has to drive. Second, are our natural resources programs, because we truly are stewards of major pieces of America. Third, is NEPA compliance, because of it's importance with what we do. Finally, the development of an environmental strategy that integrates and implements. The strategy must set the goals in a public forum. It must dedicate the resources, it must execute, and finally, it must communicate the results.

Thank you very much. I want to wish you well in the next three days. I know that you will have a good conference, and I hope that we will all learn very much from it.

Dr. Emir Metry, Moderator:
Thank you very much, Mr. Parker. I can assure you that will not be your last major speech, because we will be demanding that you can come and talk to us. It is wonderful to see, for many of us who started in this field as engineers and technicians ... and as poets. What the environmental movement needs is more poets that will tell us where we are going, and the rest of us will make it happen.

END

CROP AND PASTURE LAND CONVERSION OPPORTUNITIES FOR MITIGATING GLOBAL WARMING

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Land and owner characteristics are used to identify a national pool of 120.8 million acres of marginal crop and pasture land, on which hardwood or softwood vegetation can potentially grow. Of the 58.0 million acres for which consistent economic data on softwoods are available, 25.6 million acres can be profitably converted to forests. Establishing new forests on these lands would require $1.58 billion, which would provide an annual merchantable volume increment of 1.7 billion cubic feet. Most of the lands (22.7 million acres) are currently pasture lands with little or no potential for conversion to cropland. The remaining 2.9 million acres are currently used for row, close grown, or other crops. Factors limiting the agricultural use of these lands include erodibility, wetness, and other soil characteristics. Most of the lands (15.8 million acres) are erodible. The remaining lands (5.4 million acres and 4.3 million acres) are limited by soil characteristics, and wetness, respectively. Some of these limitations may also impede conversion to forests. Establishing forests on these lands would incorporate an average of 0.0223 Gt of carbon per year in tree biomass if trees were grown to economically optimal rotation lengths. Additional changes in understory and soil carbon would also occur. Compared to global estimates of atmospheric carbon increases such as 3.0 Gt/yr (1.4 ppm/yr), establishing forests on these lands would mitigate increases by about one percent. This corresponds to about two to three percent of United States emissions. In contrast, carbon releases of 0.4 to 4.2 Gt/yr have been attributed to global tropical deforestation. The full menu of policy options to mitigate climate changes must consider not only establishing new temperate forests, but controlling the rapid loss of existing tropical forests.

CROP AND PASTURE LAND CONVERSION OPPORTUNITIES FOR MITIGATING GLOBAL WARMING

INTRODUCTION

The role of global environmental change in policy design has concentrated attention on forested environments and the potential for growing forests to mitigate atmospheric carbon increases (e.g., 4, 10). Large areas of crop and pasture lands in the United States may be of limited agricultural value due to erodibility, wetness, and other soil characteristics (e.g., low moisture-holding capacity). Converting some of these marginal lands to forests can provide net economic gains as well as sequestering atmospheric carbon and providing other environmental benefits.

OPPORTUNITIES FOR CONVERTING CROP AND PASTURE LAND

POTENTIAL ACREAGE POOL

Land and owner characteristics are used to identify a national pool of 120.8 million acres of marginal crop and pasture land, on which hardwood or softwood vegetation can potentially grow (Figure 1).

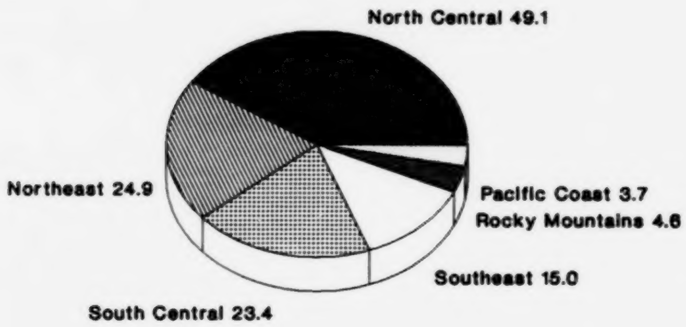

Figure 1. Acreage Pool of Crop and Pasture Land by Region (Million Acres).

The acreage pool consists of privately-owned land, that is not prime farmland, and is currently used for crop or pasture. Irrigated lands and lands growing specialty crops (e.g., horticultural crops) are excluded. Only land in Land Capability Classes III, IV, VI, and VII (8), and areas of the country capable of supporting hardwood or softwood vegetation are included (6). Most of the land is in the Northeast, North central, Southeast and South central regions, although some lands meeting the marginal criteria are found in the Rocky Mountain and Pacific Coast Regions.

The acreage pool is roughly evenly divided between lands that can potentially support softwoods and hardwoods, and between current crop and pasture uses (Figure 2). Most potential hardwood lands are found in the North Central and Northeast (36.8 million acres and 13.5 million acres, respectively) regions, particularly in Great Plains. Potential softwood lands are in all regions, but are particularly large in the South Central, Southeast, North Central, and Northeast regions (18.2 million acres, 15.0 million acres, 12.4 million acres, and 11.4 million acres); 8.2 million potential softwood acres are found in the Pacific Coast and Rocky Mountain regions combined.

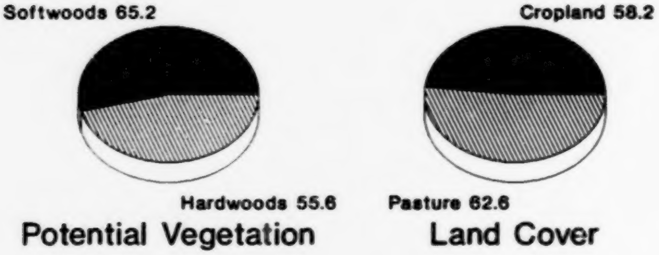

Figure 2. Acreage Pool by Potential Natural Vegetation and Current Land Cover (Million Acres).

The acreage pool is also roughly evenly divided between land currently used for crops and for pasture (Figure 2). Most of the cropland in the acreage pool (41.3 million acres) is found in the North Central and Northeast regions; 11.9 million acres are found in the South Central and Southeast Regions. In contrast the largest shares of pasture land in the acreage pool are found in the South Central (17.2 million acres) and North Central (19.7) million acres. The Southeast and Northeast acreage pools contain 9.3 million and 13.1 million acres, respectively. The remaining 3.2 million acres is evenly divided between the Rocky Mountain and Pacific Coast regions.

MARGINAL CROP AND PASTURE LANDS

Marginal lands are those lands in the acreage pool which can be converted to forests for a net economic gain. To identify these lands, economic benefits from forest use were compared to those for crop and pasture lands. Forest data were provided by the USDA Forest Service, and consist of yields, costs, and prices. Yields are based on an average of management intensities, costs and prices are similar to those used in the recent 1989 Renewable Resources Planning Act Assessment (e.g., 2). Net crop returns per acre were determined from data provided by the Soil Conservation Service for each state portion of Major Land Resource Areas in the contiguous United States. These returns per acre are based on returns, costs, and yields for sixteen major crops, which comprise nearly 94 percent of the cropland acreage used. These crop budgets are similar to those used in the Second Soil and Water Resources Conservation Act Appraisal (9). Pasture returns used are annual cash rents received for pasture land by state. Returns were compared on a state-Major Land Resource Area basis to identify marginal lands within the acreage pool.

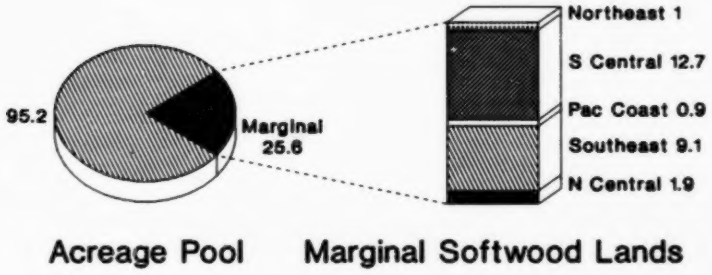

Figure 3. Marginal Land by Region (Million Acres).

Of the 58.0 million acres for which consistent economic data on softwoods are available, 25.6 million acres can be profitably converted to forests (Figure 3). Most of these marginal lands are in the South Central (12.7 million acres) and Southeast (9.1 million acres). The North Central Region includes 1.9 million acres of marginal softwood land, and the remaining 1.9 million acres are roughly equally divided between the Northeast and the Pacific Coast.

Currently, most of the marginal lands are used for pasture that has little or no potential for conversion to cropland (22.7 million acres), the remaining 2.9 million acres are used for row, close grown, or other crops (Figure 4). No marginal crop lands are in the west (either the Rocky Mountain or Pacific Coast regions); the majority of marginal croplands are found in the Southeast and South central Regions (1.2 million acres and 1.5 million acres, respectively). The Northeast and North Central regions 0.2 million acres of marginal cropland.

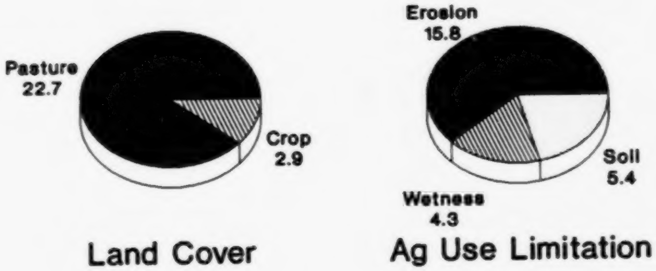

Figure 4. Marginal Softwood Lands by Land Cover and Agricultural Use Limitation (Million Acres).

The marginal softwood lands in the west consist of 0.9 million acres of pasture in the Pacific Coast region. The Northeast region also contains 0.9 million marginal pasture acres, while the North Central region (primarily in the Lake States) has double this amount, or 1.8 million acres. The bulk of the marginal pasture land is found in the South Central region (11.5 million acres), with the remaining 7.6 million acres in the Southeast region.

Factors limiting the agricultural use of these lands include erodibility, wetness, and other soil characteristics. Most of the lands (15.8 million acres) are erodible (Figure 4). The remaining lands (5.4 million acres and 4.3 million acres) are limited by soil characteristics, and wetness, respectively. Most of the land in the two southern regions is currently limited by past or potential future erosion, although erodible marginal land is also present in the North Central, Northeast, and Pacific Coast regions. Lands of limited use due to soil characteristics (e.g., moisture holding capacity) are found about equally in the North Central, South Central, and Southeast regions. Soils limited by wetness are found primarily in the Southeast. Some of these limitations may also impede conversion to forests.

OPPORTUNITIES FOR MITIGATING GLOBAL WARMING

These marginal lands provide an opportunity to mitigate global warming by sequestering atmospheric carbon dioxide. The potential mitigation possible with land conversion must be weighed against conversion costs, and other mitigation options. Establishing new forests on these lands would require \$1.58 billion (Figure 5). Most of the expenditure will be required in the South Central and Southeast regions (\$0.73 and \$0.51 billion, respectively). Establishing forests on the North Central, Northeast, and Pacific Coast Regions will cost a total of \$0.34 billion. Under a proposed \$110 million for the rural tree planting initiative in the America the Beautiful program (7), which is to subsidize 50 percent of establishment costs, the funding level must be maintained for at least 7.2 years to take pay for the opportunities shown in Figure 5.

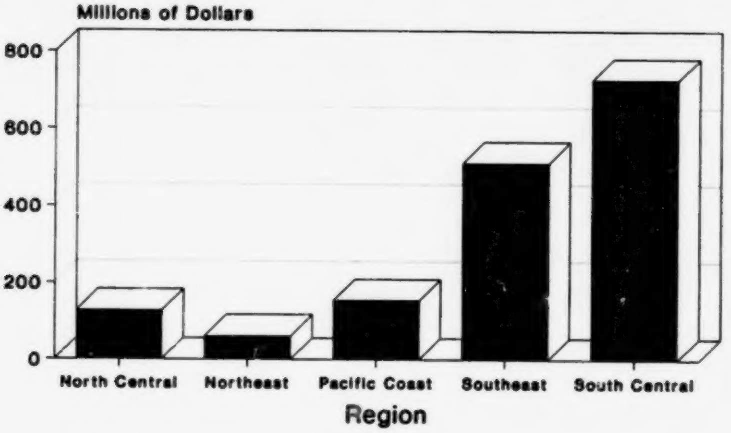

Figure 5. Conversion Costs by Region.

Creating these forests will add new acres to the existing nonindustrial forest land base (Figure 6). The additions are most significant in the South Central (11.6%) and Southeast (10.8%) regions; outside these regions, the added lands are negligible compared to existing forest area (2). When grown to the economically optimal rotation length, these lands will provide an annual volume increment of 1.7 billion cubic feet. By region, the added volume is 22 percent of projected annual harvests for the South, nine percent for the North, and three percent for the Pacific Coast (2). The amount of biomass in the first generation of these new forests is 0.568 Gt (1 Gt equals 1 billion metric tonnes). Most of the biomass is concentrated in the South Central (0.256 Gt) and Southeastern (0.193 Gt) regions. The North Central, Northeast, and Pacific Coast regions store 0.038 Gt, 0.018 Gt, and 0.063 Gt, respectively.

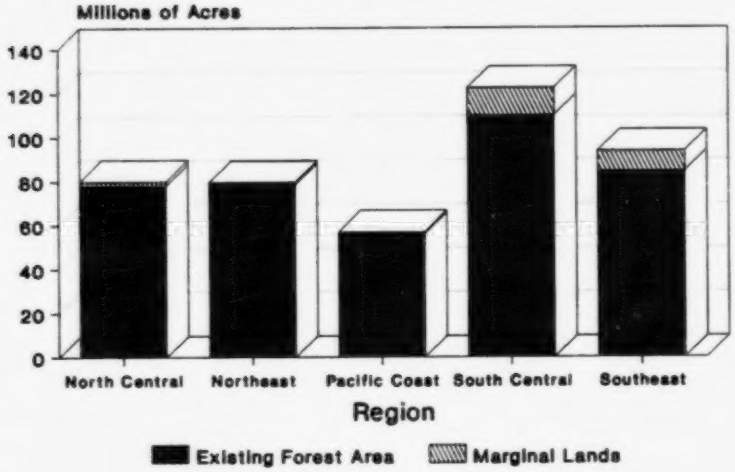

Figure 6. Potential Afforestation Compared to Existing Forest Land.

MITIGATION QUANTIFIED

The opportunities discussed here must be placed on an annual basis in order to compare them to emissions, and to quantify the mitigation impact (Figure 7). The new forests shown earlier in Figure 6 will sequester an average of 0.0223 Gt/yr throughout the economic rotation. Most of this sequestration will be in the South Central (0.0108 Gt/yr) and Southeast (0.00771 Gt/yr) regions. Additional carbon will be sequestered in North Central (0.0017 Gt/yr) Northeast, (0.000816 Gt/yr), and Pacific Coast regions (0.001348 Gt/yr). These statistics consider only the carbon in tree biomass.

Additional changes in understory and soil carbon would also occur. A better assessment of net changes as a result of land conversion would require a tally of carbon sequestered in crop and pasture ecosystems, as well as non-tree components of temperate forest ecosystems.

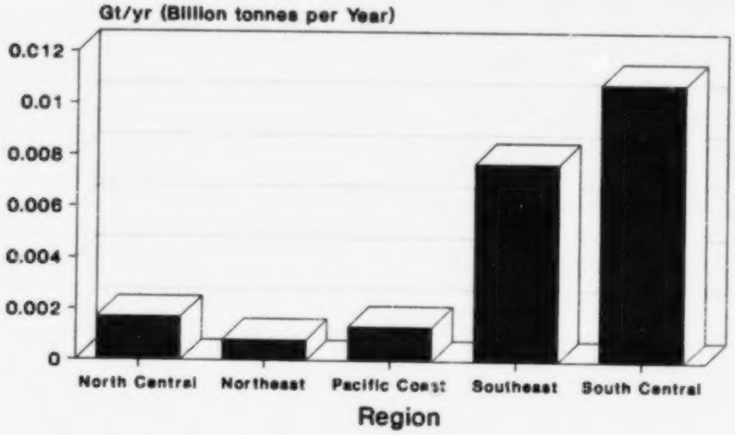

Figure 7. Potential Mitigation by Region.

Compared to global estimates of atmospheric carbon increases such as 3.0 Gt/yr (1.4 ppm/yr) (5), establishing forests on these lands would mitigate global increases by about one percent. This corresponds to about two to three percent of US emissions. In contrast, carbon releases of 0.4 to 4.2 Gt/yr (3) have been attributed to global tropical deforestation. The full menu of policy options to mitigate climate changes must consider not only establishing new temperate forests, but controlling the rapid loss of existing tropical forests.

As an aside, it should be noted that the management of existing forests can be changed to sequester more carbon than they presently do. For example, considerable management opportunities exist on temperate forests in the US (2). These fall into two broad categories, stocking control and regeneration. The former requires entry into existing stands to adjust stand density for greater growth. The latter requires reestablishing stands on existing nonstocked forest lands. Each of these options increases annual growth. Figure 8 shows merchantable (cf. total tree biomass, Figure 7) biomass increments that could be achieved if all management opportunities identified in (2) were undertaken, as well as the afforestation opportunities presented earlier in Figure 7. Clearly, an integrated strategy, with emphases on establishing new forests, adapting the management of existing forests, and controlling the loss of forests has much to recommend itself.

CONCLUSIONS

Converting marginal lands to forests may require both public and private funds. The cost of land use change must include not only land conversion costs (e.g., forest establishment) but also opportunity costs of forgoing other revenue-producing land uses when they are present. With perfect markets and in the absence of risk, landowners who would be economically better-off with forests than with crops or pasture would change uses without a subsidy. For example, in the Southeast and South Central regions, net economic gains from conversion are possible on 21.8 million acres. Subsidies for the difference between forest income and agricultural income would hypothetically be required to convert the 10.4 million acres remaining in the Southern marginal acreage pool. If establishing forests is to become a policy goal, research must now identify economically-efficient policies for land conversion, and evaluate these policies in the context of risky or imperfect markets for stocks and flows of forest benefits. Benefits and costs of these mitigation strategies must be compared with other policy options to find the most efficient set of responses to climate change.

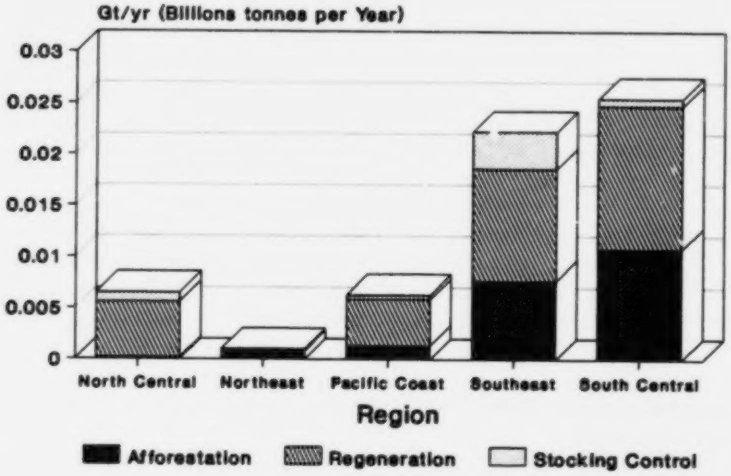

Figure 8. Potential Integrated Mitigation.

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TOXIC WASTE TRADE IN AFRICA AND THE CARIBBEAN: FROM REGULATION TO POLLUTION PREVENTION

BY

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BACKGROUND

Industrialized countries generate 90% of the total global hazardous waste produced. Greenpeace has verified that between 1986 and 1988, 3.17 million metric tons of waste were shipped from countries in the industrialized North to poor countries in the South. Recent proposals to ship wastes to the countries of sub-Saharan Africa, some 17.4 metric tons per year, approximately the total volume produced in the EEC, were opposed by developing countries which ultimately refused to accept these exports.

The issue of transnational toxic dumping was dramatized by the cargo ship, Khian Sean which carried 14,000 tons of toxic incinerator ash from Philadelphia to a number of countries in Central America, the Caribbean, Africa and the Indian Ocean for two years in search of a place to dump before leaving 3,000 to 4,000 tons on a beach in Haiti. The manifest described the ship's cargo as fertilizer. The remainder was reportedly dumped in the Indian Ocean. These episodes reflect the effects of increased regulation of toxic and hazardous pollutants in the U.S. and the high cost of disposal. Incinerator ash may contain high levels of dioxin and heavy metals.

Another episode from 1988 revealed that 15 million tons of U.S. and European pharmaceutical and tannery wastes were due to be imported into Guinea Bissau in exchange for 600 million dollars, four times the country's GNP and two times the national debt, but proper disposal of the same waste in the country of its origin would have cost from ten to twenty times more. These factors provide incentives to producers of hazardous waste to seek disposal in areas outside the U.S. and Europe.[1]

The Resource Conservation and Recovery Act (RCRA) Section 3017 requires documentation of wastes, notification, and prior consent before shipment of hazardous waste between countries participating in the trade. Regional groups, such as OECD and the EEC allow shipments, and the regulations such as the 1984 EEC directive on transfrontier movement of wastes between member states cover movements designed for export outside the EEC. However, by 1988 only three countries in the EEC had incorporated the directive into regulations which focus on the end of the hazardous waste life-cycle. The regulations beg the question whether conventions on notification and prior consent between countries, and documentation of wastes can protect the people in developing countries from adverse health impacts and further environmental degradation, or whether more preventive measures including a total ban on exports of countries in the South, is more in order.

The following sections include a review of domestic factors underlying toxic dumping in Africa and the Caribbean, considering the generation and production of wastes in the U.S. and Europe. We explore similarities between proposed EPA Regulations and the Basel Convention, the social, economic, political and environmental consequences, and the application of pollution prevention principles which can achieve greater protection of human health and the environment.

1. B. Wynne, "The Toxic Waste Trade: International Regulatory Issues and Options," Third World Quarterly, Vol. 11, No.3, July 1989 p. 125

DOMESTIC FACTORS AN THE INTERNATIONAL WASTE TRADE:

Industries in the U.S. generated at least 2,4000 lbs wet weight per person per year, including some non-RCRA regulated wastes such as PCBs and industrial scrubber sludges. This excludes wastes from companies generating less than 1,000 kilograms, waste from clean-up of Superfund sites and hazardous waste that is nuclear, agricultural and mining. Overall, the U.S. generates over 250 million metric tons per year depending upon types of waste included. Waste varies by definition. For example, recycled oil is not regulated as hazardous waste. The figures above do not include the amount of waste handled illegally.

Most RCRA regulated wastes have been managed on land by deep well injection, landfills and surface impoundments. Examination of RCRA permits indicates a decline in land disposal of hazardous waste with implementation of the Hazardous and Solid Waste Amendments (HSWA).

Disposal facilities decreased significantly when surface impoundment was required. It is not clear what is happening to waste previously handled by such waste diposal facilities. Alternative types of capacity are also declining with utilization of management facilities, e.g. incinerators at 90% capacity by the end of 1985. Current landfill capacity has less than 15 years remaining at current rates of use. Hazardous wastes represent a special problem arising from production of by-products in chemical industries, and the manufacturing processes , and the need to dispose of these by-products. While it is difficult to specify the amount generate annually, it includes:

(1) cyanides
(2) paint residues
(3) metal wastes
(4) organic solvents
(5) material containing arsenic, asbestos, mercury and cadmium.

Because unsafe disposal of these wastes can cause severe damage to human health and the environment, industrialized countries have regulations governing disposal. The long term solution is not so much safe disposal as to prevent the generation of toxic waste by changing production processes and product design.

The international trade in hazardous waste is a complex business. It is almost impossible to document and effectively control that trade by regulations, given the diverse agents involved in consignments and the nature of deals between generators, transporters of hazardous wastes and receiving countries. This situation also highlights a contradiction between national sovereignty and the international impact of environmental degradation.

The principal causes of the growth in this trade include increasingly stringent regulations, public opposition to landfills and incinerators, and rising costs of hazardous waste disposal in the industrial countries such as the U.S and in Europe. These developments have resulted in both legal and illegal shipments of toxic waste to developing countries in Africa and the Caribbean.

The pro-export groups argue that a ban on waste trading would deprive poor countries of a means to earn hard currency, and, that lack of clear distinction between toxic and raw materials, recycled as inputs for industrial processes would curtail waste management technology transfer, and discourage industrial development. Upon this argument, toxic waste is like any other commodity and it assumes that free markets would assure efficency and equity. This view fails to address the underlying structural problems.[2]

For example, in the U.S. the 1984 Amendments to RCRA tightened landfill requirements for municipal wastes and curtailed disposal of untreated wastes in landfills, deep well injection, and industrial incineration. The cost of hazardous waste disposal which can run as high as $2,400.00 per ton in the U.S., results from expensive treatment and disposal methods, and lack of certified hazardous waste handling facilities. The generators facing this situation can circumvent the EPA regulations by dumping unknown quantities of wastes in developing countries at prices as low as $2.50 per ton.

The European countries, members of the EEC generate 30-40 million tons of hazardous wastes each year, but only have the capacity to dispose of 10 million tons each year. Since 1986, both the U.S. and Europe shipped hazardous waste to countries including Brazil, Haiti, Lebanon, Mexico, Nigeria, South Africa, Syria, Venezuela and Zimbabwe.

The developing countries generally lack the capacity to ensure safe handling disposal or treatment of hazardous wastes. The waste imports dumped in vulnerable countries with huge debt burdens, and poverty, reproduce the environmental management problems and failures of industrialized countries.

The problem of hazardous waste exports and toxic dumping is connected with proverty and development at the national and international level. The general situation is exacerbated by wide differences in the stages of industrial development and the capacity for effective regulation of waste exports by countries involved in the hazardous waste trade. In a sense, the problem of hazardous waste disposal is the problem of poor communities both here and overseas, impoverished communities whether in Alabama or Zaire.

2. B. Wynne, Ibid pp. 123-128.

The poor of urban and rural areas of the U.S., Africa, the Caribbean and elsewhere, face environmental abuses caused by failed government policies which result in the disproportionate exposures to pollution and hazardous materials. For example, these exposures involve hazards such as contaminated drinking water from lack of sewerage, human and chemical wastes, and unknown quantities of toxic materials from location near or in garbage dumps, toxic dumps and hazardous industries e.g. Bhopal.

CONSEQUENCES OF THE INTERNATIONAL TOXIC WASTE TRADE:

Toxic dumping is thus partly a consequence of the policies and regulations governing export of hazardous wastes and export of hazardous wastes and disposal of toxic substances. The U.S. Office of Science and Technology Policy describes the regulations as a two stage process: Stage 1 uses facts, empirical data and scientific judgment to characterize human exposure and risks. Stage II uses values, social and political judgments to decide regulatory action based upon significance of the risk, benefits of the agent and cost of its control.[3]

In addition, current national policies and the international regulatory framework under UNEP auspices, i.e. the Basel Convention[4] allow toxic waste trade on the basis of a documentary system with notification and consent. These regulations favoring exports might be partly explained by the cultural biases of the policy actors and interest groups.[5]

The trade in hazardous waste between industrialized and developing countries is premised on the belief that land disposal of hazardous waste substances is reasonably safe. The underlying assumption is that these wastes would degrade into harmless products or stay where they are put. These assumptions have been proven wrong since many of these wastes do not degrade, degrade very slowly, or degrade into substances that are hazardous to human health and the environment. The waste products can also migrate into water or be moved by wind into storm water in other locations, and pose significant risks to people's health long after disposal. The risks include birth defects, cancer, genetic damage, neurological defects and liver and kidney damage.[6]

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[3] Alice S. Whittemore, "Facts and Values in Risk Analysis for Environmental Toxicants", Risk Analysis, Vol. 3. No. 1, 1983, p. 23

[4] Arts. 6-14, 20, Final Act of the Conference of Plenipotentiaries on the Global Convention of the Control of Transboundary Movement of Hazardous Wastes, UNEP/1G.80:. 12, 22 March, 1989. For a critical account of the Basel Convention and the international toxic waste trade generally, see Wynne, "The Toxic Waste Trade: International Regulatory Issues and Options", note 1, supra pp. 120-146. According to Wynne, the Convention ended negotiations in 1989 in a confused and unsatisfactory manner, leaving major loopholes and disagreements unresolved. (ibid, p 122).

[5] On the relevance of cultural theory, and cultrual bias in environmental management, see Susan J. Buck, "Cultural Theory and the Management of common Property Resources", Human Ecology Vol. 17. No. 1, 1989, pp. 101-116.

Hazardous chemicals can cause major public health consequences when discharged into the environment, e.g. mercury poisoning at Minamata Bay in Japan. Highly toxic effects result from low level exposure to polychlorinated biphenyls (PCBs) ingested in small quantities over a period of time[7].

Consequences of dumping in Africa include charges of "toxic terrorism" by most leaders at the 1988 OAU summit in Addis, Ababa, Ethiopia. The Afican leaders adopted a resolution to further agreements on a ban and prevent any arrangements with industrialized countries on dumping nuclear waste and hazardous industrial waste. Nigeria called the special regional summit of West African Countries (ECOWAS) in Lome, Togo. The West African leaders intiated "Dumpwatch" to monitor dumping.

Western reaction include denials, for example, a May 1988 Voice of America broadcast denied that any toxic waste from the U.S. had been shipped to Guinea; and, equated the need for hard currency with the "need" to dump toxic waste, and indicated that there is no evidence of widespread shipments of dangerous materials to poor countries[8]. A number of bills introduced in the U.S. Congress in response to the reaction to toxic dumping, would require countries to manage U.S. waste exports by U.S. standards. These countries would be subject to requirements in U.S. environmental laws. The proposed legislation would cover supposedly non-hazardous waste including municipal solid waste and incinerator ash. The U.S. and importing countries would negotiate agreements that include: prior consent by the receiving country, exchange of information on waste management, and access to foreign disposal facilities for U.S. inspectors to ensure proper management of U.S. wastes. The Bush Administration has argued against the legislation on foreign policy grounds[9].

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6. State of the Environment: A View towards the Nineties, Conservation Foundation, Washington, D.C. p. 156

7. ibid, p. 157.

8. See "Toxic Dumping Alarms Afica", TransAfrica Forum", Issue Brief, Vol. 7. NO. 3, Winter 1988-89, pp. 1-3.

9. Hazardous Waste, "House Bill Would Require Foreign Countries to Manage Waste Exports by U.S. Standards", Environmental Reporter, 6-2-89 See also Inside EPA, 21 July 1989.

INTERNATIONAL RESPONSES TO THE TOXIC WASTE TRADE:

Transboundary movements of hazardous waste have spurred a number of regional agreements to regulate the toxic waste trade. On one hand, these include decisions by the OECD and the EEC which permit international trade in hazardous waste, while attempting to regulate it. On the other hand, the OAU, ECOWAS and CARICOM and forty other countries have banned importation of wastes.[10] These divergent international responses led to the UNEP sponsored negotiations on the global convention mentioned above.

Further in 1988, the European Parliament joined the African, and Caribbean Parliamentary Association to support a ban on international waste trade.[11] In 1989, the 4th Lome Convention included in its main areas of cooperation on environmental protection, a comprehensive approach involving a ban on moving toxic and radioactive wastes.[12]

However, as late as 1988, sixteen African countries were linked to toxic dumping. A number of individual African states signed contracts to accept industrial waste from Western European states and the U.S.. For example, Benin contracted to accept industrial waste containing asbestos and cyanide. At the same time, South Africa accepted a shipment of New Jersey sludge waste containing mercury. On the other hand, Guinea-Bissau cancelled two contracts that would have dumped on their territory 1/2 million tons of industrial and pharmaceutical waste from Switzerland.

At the eleventh Session of the Caribbean Development and Cooperation Committee (CDCC), the participating Governments requested that the Economic Commission for Latin America (ECLA/CC) present at its twelth session in 1989, a report on the damage caused to the region by the international trade in hazardous waste. The CDCC resolution condemned these activities carried out by enterprises to the detriment of the ecological security of the region and which adversely affect the economic and social development of the countries and the health of their populations.[13]

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10. For Instance, the Nigerian Government, after seizing an Italian ship which had dumped toxic waste in Nigerian territory in 1988, broke off diplomatic relations with Italy, and also madated the death penalty for those engaged in subsequent toxic dumping. See generally, "Toxic Dumping Alarms Africa", TransAfrica Forum, Issue Brief, Vol. 7. No. 3, Winter 1988-89, p. 1,3.

11. See Wynne, note 1. supra, p. 122.

12. For the Convention, see The ACP-EEC Courier, No. 120 March-April 1990. pp. 12-19. Arts. 4,6,14,16, 33-41.

13. Caribbean Conservation News, Vol. V. No. 5, March 1989. p.2

POLLUTION PREVENTION STRATEGIES

The protection of environmental resources in developing countries can best be served by a total ban on waste exports in the view of many environmentalists. The reasons include: damage to U.S. foreign policy interests from the issue of toxic dumping; crippling financial liabilities as in the case of Union Carbide at Bhopal in India, and considering ozone depletion and the greenhouse effect, the calls for a halt to deforestation in developing countries seem hypocritical and self-serving by countries applying pressure, and, which are at the same time engaged in toxic waste trade.

Pollution prevention strategies have demonstrated benefits in Europe and the U.S. As such, the cooperation between government and industry involves changes in government polcies, industry production methods and manufacturing processes, as well as the organization of work. Research and development of low and non-waste technologies, and transfer from industrialized countries to developing countries and indigenous technology transfer from developing countries to developed countries, would be more in order to prevent hazards from causing disease, or injury to human health. Because it is feasible to voluntarily reduce production of wastes in the U.S. by current technologies and by up to 50 percent the next few years[14], this approach would have major impact on the "need" to export hazardous wastes and products.

Incentives for pollution prevention include legislation with provisions for a total ban on export of hazardous waste to countries without the capacity for handling these wastes. Considering U.S. expenditure of up to $80 billion U.S. per year on regulatory activities, and $300-500 billion for cleaning up toxic waste sites, countries impacted by toxic dumping do not have the resources or facilities to "manage" waste imports by U.S. standards, along with excessive debt, lack of basic sanitation, and need for potable water supplies.

The integration of pollution prevention strategies with traditional primary public health prevention would combine education and legislation such as a ban on waste exports, and maximize source reduction. Strategies outlined below involve fundamental changes in behaviour, in the activities of individuals, groups, government and industry.

14.J.S. Hirschorn, "Cutting Production of Hazardous Waste, "Technology Review, April 1988. p.54.

Pollution Prevention Strategies

Individuals: Increase awareness of environmental hazards and health effects of toxic wastes and products; understand full costs of waste; obtain technical information and assistance on new technologies.

Groups: Information exchange; scientific and technical collaboration; promote policy changes at national and international levels; technology development and transfer.

Communities: Muncipal ordinances e.g. bans, restrictions on land use; integrated pest management; cooperative agreements on pollution prevention shared technical assistance, information resources.

Government: Legislation to ban waste exports and imports, as well as regulating toxic products e.g. pesticides, integrated pest management as prority in agricultrual policy; low-input farming to also reduce chemical fertilizer use; fund technology development and transfer.

The resources for implementation of pollution presention would be provided by country governments, the United Nations Environment Program, and regional development banks. The UNEP's "Provisional Notification Scheme for Banned and Severely Restricted Chemicals", provides voluntary guidelines on notification of regulatory decisions and export shipment or efforts to ban or severely restrict chemicals including pesticides. The IDB is creating a fund to mobilize resources for environmental projects in Latin American and the Caribbean, that would finance preventive and curative measures. Dr. Noel Brown, UNEP, has called for the establishment of an Environmental Security Council to study environmental problems prior to the international conference in 1992. These collective measures will enhance pollution prevention in the 1990s.

CONCLUSION:

The most effective measures for dealing with the international toxic waste trade clearly involve a ban on waste exports, requiring wastes to be managed and disposed of by the producer countries.

This position is advocated by environmentalists who assert that some existing conventions legitimize the expanding global waste trade. Under Section 12a of the Toxic Substances Control Act (TSCA) EPA can restrict export of chemical substances if the Administrator finds "unreasonable" risk of injury to health within the U.S. or the U.S. environment.

Previously, President Carter issued an Executive Order at the end of his term in 1981 restricting export of hazardous waste. This would have banned most exports of products that represent a significant threat to human health, and safety of the environment, if exporting them would cause clear and significant harm to American foreign policy interests. That Order was revoked by President Reagan shortly after he took office.[15]

Full implementation of recognized pollution prevention strategies as a priority in the industrialized countries would eliminate or at least reduce the international trade in toxic waste. The better approach is to deal with the problem at the source or sources of production, rather than attempt to eliminate the problem by an export solution. To shift pollution elsewhere, at best delays the fundamental changes necessary in the organization of work, production methods and technological innovation. This export policy does not resolve environmental and ecological problems which ultimately have to be faced in the era of the so-called "Global Village".

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15. See note 55, Faith Halter, "Regulating Information Exchange and International Trade in Pesticides and Other Toxic Substances to Meet the Needs of Developing Countries", Columbia Journal of Environmental Law, Vol. 12. No. 1. (reprint), p. 12.

INTEGRATED PERMITS AND MULTI-MEDIA POLLUTION PREVENTION

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ABSTRACT

That we produce wastes is an inescapable fact of life. How we manage and dispose of these wastes is important, because it affects the environment we live in. Over the years, we have seen the quantities of wastes generated continue to increase. We have also seen that to dispose of these wastes in an environmentally safe manner is taking considerable resources. Unless we reduce the quantities of wastes we generate, we will devote more and more resources to manage and dispose these wastes.

It does then make sense to explore approaches and tools that would reduce the quantities of wastes that are generated and disposed. Integrated permits is one such tool. Briefly, an integrated permit coordinates various media-specific requirements for releases to air, water and land to minimize cross-media transfers of pollutants. Such a permit would be based on an assessment of all releases from that plant.

To test the feasibility of issuing an integrated permit and to develop a broad methodology for conducting plant-wide assessments, EPA and Amoco have jointly initiated a project. Under the project, we will take a wholistic look at the releases from their refinery in Yorktown, Virginia, develop multi-media pollution prevention and pollution control strategies for the plant, rank these strategies using a number of criteria and assess incentives and impediments to implementing these strategies. The methodologies developed in this case study will be applicable at other refineries and other industries.

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The views expressed here are the author's and should not be construed as the position of the Environmental Protection Agency.

That we produce waste is an inescapable fact of life. How we manage and dispose of these wastes is important, because it affects the environment we live in. Over the years, we have seen the quantities of wastes generated continue to increase. We have also seen that to dispose of these wastes in an environmentally safe manner requires increasingly more care and more resources. Unless we reduce the quantities of wastes we generate, we will devote more and more resources to manage and dispose these wastes.

There is greater awareness that economic activity and environmental protection are not mutually exclusive. The simple fact is that if less wastes are generated, less resources have to be devoted to treatment prior to disposal. Improved efficiency of production processes can yield more product for the same units of input, thus lowering costs of production. However, new technologies that can provide existing products while generating less pollution are needed but may not be readily available for all industries. Developing such technologies and making them available on a broader scale will require both resources and time.

In the mean time, such factors as greater public awareness of the growing problem of waste, wider dissemination of the production technologies that generate less waste, increasingly higher costs of treating and disposing the wastes that are generated, and the rising concerns over future liabilities associated with improperly disposed wastes have spurred activities to reduce the quantities of wastes that are generated. These activities can be described and grouped into four broad categories: (1) source reduction, (2) recycle, (3) treatment, and (4) safe disposal. EPA has also recognized that further improvements in environmental quality will be achieved by following the above hierarchy of waste generation and management --reduction in the quantities of wastes generated prior to treatment and disposal.

HISTORY OF THE ENVIRONMENTAL LAWS

The evolution of the environmental laws in the U.S. is well documented. In brief, the Environmental Protection Agency (EPA) was created in the 1970s to implement environmental legislation that Congress passed. These laws were passed as the nation dealt with one crisis at a time. The Clean Water Act addresses the problems of water pollution, Clean Air Act deals with air pollution, Federal Insecticide Fungicide and Rodenticide Act regulates the use of pesticides, Toxic Substances Control Act controls chemical products, Safe Drinking Water Act protects drinking water supplies, Resource Conservation and Recovery Act

(RCRA) deals with solid and hazardous wastes, and Superfund Act (CERCLA) deals with contamination from past hazardous wastes disposal practices.

The main focus of the three laws that address releases to air, water and land has been command and control regulations that rely on the end-of-pipe controls. Regulations that implement the requirements of the Clean Air Act regulate releases of contaminants into air. Regulations under the Clean Water Act regulate discharges of contaminants into water. Regulations under RCRA ensure that hazardous wastes are properly managed when they are disposed in a landfill. By focusing on preventing the contamination of specific media, these regulations largely ignored the potential of transferring wastes from one media to another. Furthermore, we do not have sufficient data to assess the magnitude of these inter-media shifts and the impact these shifts may have on the environment.

That, however, is changing too. There is a growing realization among regulators that the end-of-pipe focus is not adequate. The confluence of a number of factors is causing a shift in thinking--it is no longer adequate to protect specific media; we have to be concerned with the whole environment. It is in the best interest of the nation to reduce the quantities of wastes we generate (improve efficiency of resources used and lower production costs) which in turn will reduce the cost of treatment and disposal. Resources saved by having less wastes to treat and dispose can be used for more productive uses elsewhere in the economy.

It is reasonable to ask--if source reduction and recycling is such a good idea why have these not been implemented widely? A number of factors can account for this seemingly lack of interest in implementing the concept--focus on compliance with media-specific requirements; and lack of readily available technologies, their costs and payback period (costs are immediate but the payback period is long). It is also possible that treating end-of-pipe problems under strict compliance schedules does not provide sufficient time (and resources may be lacking too) to track backwards in the production processes to reduce pollution that is generated.

On the other hand, such large corporations as 3M, Dow, Chevron, Amoco Chemical and Monsanto embraced "pollution prevention" some time ago and have been implementing source reduction and recycling in their plants. They have documented successes in reducing the quantities of wastes generated and saving money both from less resources used and from lower waste treatment and disposal costs. I should note that pollution prevention has not been as easily achieved at smaller facilities because these facilities are constrained by limited resources.

A number of tools can be used to implement pollution prevention--reduce wastes generated rather than transferring them from media to media. One such tool is an integrated permit, also known as a cross-media permit. Briefly, an integrated permit coordinates various media-specific requirements for the whole facility to minimize cross-media transfers of pollutants. A more detailed definition is presented later in the paper.

INTEGRATED PERMITS

The focal point in each of our media programs has centered on permits and compliance with them. EPA and state delegated permitting programs are the key tools that are used to control pollution across the country. They form the critical link in the implementation of environmental control mandated by national legislation.

The number of facilities that discharge wastes and the volumes of wastes regulated under various permits is quite large. For example: The National Pollutant Discharge Elimination System (NPDES) permit program governing industrial waste water discharges regulates approximately 65,000 industrial and municipal direct dischargers, 10,000 combined sewer overflows and over 100,000 storm water discharges. Approximately, 5,500 facilities subject to RCRA permitting managed 272 million metric tons of hazardous waste in 1986. The 1988 Toxics Release Inventory data revealed that large manufacturing facilities released 4.6 billion pounds of toxic chemicals to air, water and land. A large portion of these releases comply with legally permitted limits set by facility-specific permits written under the Clean Air Act, Clean Water Act, and the Solid Waste Disposal Act (RCRA).

There are a large number of cases where compliance with a media-specific requirement has resulted in increased releases to other media. For example: Wet scrubbers used to comply with the air pollution requirements generate waste water. This waste water must be treated prior to discharge. In addition, sludge generated in the waste water treatment system has to be disposed in a landfill. However, if the facility had complied by installing a dry bag house, treatment would have generated only sludge but not waste water, thus saving the cost of an additional treatment step.

Integrated permits could represent a huge potential for institutionalizing pollution prevention and forcing it to happen nationally. The potential environmental gains are also enormous as pollution prevention conditions are written into permits to reduce the amount of pollution generated. In addition to the inclusion of new permit conditions, the permitting processes can be vehicles for education, stimulating development of new technology and technology transfer, and for providing incentives to industries and municipalities to conduct additional pollution prevention activities.

Scope of the Examination

Since neither government nor industry have the luxury to stop what we are doing and design a new pollution prevention-based permitting system, we must start by examining how to leverage and fine tune the existing permitting systems. Currently, the permit processes for air, water and waste function independently and address different pollutants, time frames, and performance criteria. As such, they do not promote coordination and tradeoffs between permits which might provide better environmental results. An integrated permit would coordinate permitting processes of various media, and would include all relevant media-specific requirements for the facility. These integrated permits may contain tradeoffs among media-specific requirements that reduce overall pollution and would encourage the reduction of pollution generation and subsequent release.

The need for a studied approach for incorporating pollution prevention into permitting arises from the complexity of the permitting system and due to the potential for cross-media transfers. This approach, however, has to be flexible to account for differences between industries and between plants within an industry. With both EPA regional offices and States issuing permits (sometimes to the same facility for the same program) to literally thousands of facilities, and several types of permits for a facility with different schedules, EPA will want to ensure that it selects appropriate approaches for incorporating pollution prevention into a facility's permit.

EPA assessed the feasibility of issuing integrated permits using information from Massachusetts and New Jersey. We found that the present permit system is designed to address environmental threats in each media as they arise and are quantified. However, multi-media issues require a broader perspective, but the media-specific data being collected does not facilitate such a broad overview. We did conclude that integrated permits do represent a potentially effective way of dealing with pollution prevention and other multi-media issues.

CASE STUDY WITH AMOCO CORPORATION

In November 1989, EPA and Amoco jointly initiated a project to review pollution prevention alternatives at an industrial facility. Amoco offered its refinery at Yorktown, Virginia for the case study. The study will assess the feasibility of issuing integrated permits as well as develop plant-wide strategies and options for reducing pollution. Specifically, we will (1) inventory all current releases to the environment; (2) develop possible multi-media pollution prevention, recycling and emission reduction options; (3) assess relative costs, benefits and impacts associated with different options; and (4) identify present and potential barriers and incentives to implementing these different pollution prevention options.

The study will be conducted in two phases. In Phase I, under Amoco's lead, we will focus on data collection. Specifically we will collect background information on the refinery, including process descriptions; existing permits for air, water and solid wastes; and current treatment technologies. We will also assemble information on the releases to the environment, including air, surface water, solid waste and ground water; population distribution around the plant; drinking water sources; other industrial emissions sources and environmental studies. To establish a better relationship between releases to the environment and their specific sources, Amoco will collect additional data through sampling and monitoring. This phase is scheduled for completion by December 1990.

In Phase II, we will jointly analyze the data we collected in Phase I. Specifically, we will develop multi-media/cross-media pollution prevention options and strategies; define ranking criteria for evaluating options, including such factors as technical feasibility, exposure/impact assessment, mass loading/release, cost/economic impact, resource utilization and cross-media transfers; rank options and evaluate rankings; identify the obstacles and incentives for implementing options, including legislation, training, regulation, worker safety, uniqueness of the facility, timing of permits and data availability. We are also planning to have the project workplan and the findings reviewed by an outside group of experts. We expect to complete Phase II by October 1991.

Goals of the Project

The project has a number of goals. We expect the case study to specifically:

- Establish a decision-making framework which would address how limited resources--time, people, and capital--can be focused effectively to achieve desired environmental results.

-Develop a systematic, site-wide analysis of refinery emissions.

-Define and rank potential options for waste reduction, recycling, and emission controls using a variety of ranking criteria. These options will have a multi-media focus and would consider cross-media transfers as a factor.

-Identify how this framework can be used by government and industry at other locations and facilities.

- Identify key factors--technical, legislative, regulatory and economic--which currently obstruct or promote pollution prevention.
- Evaluate current permits to identify how they discourage pollution prevention and develop possible alternative permitting approaches (including integrated permits) which support pollution prevention activities and discourage cross-media transfers.

Potential Benefits of the Project

There are many potential benefits associated with this project. Some of these benefits are summarized below.

1. This case study will allow us to take an integrated approach to a variety of environmental issues, reviewing a facility on a wholistic basis. A number of piecemeal programs can be examined comprehensively, with the possible synergism that multiple view points and disciplines can provide.

2. We will develop a methodology and data bases to assess and prioritize environmental issues and to facilitate long term capital expenditure planning on a plant-wide basis. This is necessary because there are not enough resources to work on all the issues that arise simultaneously. Evaluating the results of different strategies will allow us to focus on those issues first that provide the most benefits.

3. We expect to find some emission sources for which there is no technically practical remedy at this time. These will provide new research opportunities for both EPA and Amoco. One example that readily comes to mind is the effective elimination of oil-water emulsion which is major waste load

in waste water discharges but has no good solution at this time.

4. We are hopeful that plant-wide assessments and data will identify opportunities for environmental improvements beyond what has been achieved under the current media-specific regulatory system.

5. Integrated permits would provide opportunities for coordinating media-specific pollution control requirements and thus minimize cross-media transfers.

6. The findings of the case study will provide information that could prove useful for future legislative initiatives.

To summarize, the Amoco case study offers a unique opportunity to take a careful look at a refinery in a wholistic manner to identify specific emission sources, their impacts, and evaluate possible multi-media reduction alternatives that minimize cross-media transfers. In addition, the case study will produce a methodology that will have broader application and use in future pollution control efforts.

POLLUTION PREVENTION IN THE 21ST CENTURY: LESSONS FROM GENEVA

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The international community is in the process of developing a multiplicity of pollution prevention policies and strategies. In the past year a number of major global forums have helped shape the nature of these efforts. These have included "Waste Minimization and Clean Technology: Moving Toward the 21st Century," held in Geneva; the Fourth International Conference on Environmental Future (Budapest); and "Environment-Pollution-Development" (Rabat). These forums have identified certain commonalities in pollution prevention technology and management, as well as some evident trends in policy development. Prominent among these is the evolution of pollution prevention efforts into essentially three economic levels: Developed, Emerging, and Developing.

A variety of strategies--with widely differing levels of government/private sector interactions and transnational cooperation--characterize pollution prevention efforts globally.

An analysis of international efforts in the field indicates five basic elements common to viable pollution prevention program planning for the 90s and beyond.

Events of the past year and a half make it clear that the world is moving from a mode of reaction to one of prevention. In foreign policy and international relations, large militaries are giving way to sizable diplomacy, aid, and assistance programs. In economic competitiveness it has become increasingly evident that enhanced productivity is a far more effective tool than is a system of protective tariffs. Global energy policy has moved toward emphasizing increased fuel efficiency as a better way to solve energy problems than trying to keep energy prices at artificially low prices. And in efforts to upgrade and protect the biosphere, the preventive, front-end approach is now viewed as a much better long-range strategy than are remediation, treatment, and end-of-pipe control efforts.

Few people disagree on the inherent benefits of preventing pollution. The adage that reminds us it is better to teach someone to fish than to give that person a supply of fish each day is one that virtually everyone would like to apply to environmental management: It is better to avoid having to solve the problems of environmental pollution instead of, every day, having to try to manage these problems.

The major question asked in every corner of the globe, however, is: Will mandating pollution prevention systems slow economic activity? Will pollution prevention cost more than it is worth?

Experience is showing that, in fact, all economies will benefit more by practicing new prevention techniques than by practicing business as usual in environmental management. Pollution prevention may actually save considerable amounts of money and increase productivity--whether on the farm or in industry.

DEFINING POLLUTION PREVENTION

What is pollution prevention? Pollution prevention can be defined as any change in an economic activity--whether technological or management-based--that leads to the generation of less pollutants per unit of production than generated before the change was made.

Pollution prevention made its international debut a decade and a half ago. But it was not called pollution prevention. The term then was non-waste technology. The first United Nations Economic Commission for Europe Seminar on "Principles and Creation of Non-Waste Technology" (NWT-I), held in Paris in 1976, laid out strategies for the development of a systems approach to manufacturing in which resource inputs and pollutant outputs would be minimized at each step of production.

In the ensuing years since NWT-I several terms have been coined to describe front-end approaches to environmental management. These include clean technology, low and non-waste technology, waste reduction, source reduction, waste minimization, and pollution prevention. Pollution prevention appears to be the term emerging in the 1990s to connote efforts to prevent the generation of environmental degradation.

At that Paris conference was a gentleman named Joseph Ling from the 3M Company, a manufacturer with facilities in many countries. Dr. Ling talked about a new program he was starting at that time called "Pollution Prevention Pays," or 3P. Few of us in the conference room had much of an idea of what he was talking about. But we soon found out. By 1988, the 3P program had saved 3M Company over $800 million in worldwide operations, and prevented the contamination of billions of gallons of water per year.

The 3P program has been based on technological and management advances that a) reduced environmental emissions and b) resulted in production costs lower than those associated with the previous more polluting method. It has clearly demonstrated that through careful application of systems principles, environmental protection and economic advances can be compatible.

It has taken the nations of the world a long time, generally, to work into the pollution prevention mode. While the UN meeting set out principles in 1976, it was not, for example, until 1988 that the US Environmental Protection Agency established its Pollution Prevention office, and it was not until a few months ago that the Agency upgraded this office to a status where pollution prevention will be substantively interjected into environmental policy decisionmaking.

The global pollution prevention pace is, however, quickening, and the well-attended international forums taking place in recent months attest to this. The recently concluded International Conference on Environmental Future, e.g., passed a "Budapest Imperative" calling for accelerated efforts by government to curtail waste and prevent it at the source. "Environment-Development-Pollution," a unique multi-nation colloquium spearheaded by King Hassan II of Morocco, featured pollution prevention as an environmental policy management strategy. The Declaration of Chellah, emanating from this meeting, urged accelerated prevention efforts.

WMCT-21

In Geneva, in mid-1989, a conference on "Waste Minimization and Clean Technology: Moving Toward the 21st Century" (WMCT-21) brought together representatives of 25 nations to discuss over a period of several days philosophies, strategies, and specifics of pollution prevention around the world. From WMCT-21 it was evident that a wide spectrum of individuals and institutions now embrace the prevention concept. The challenge articulated in Geneva was to shift out of first gear in international waste minimization and pollution prevention efforts and to match resources--human, technological, and economic--with specific needs.

This resource matching will require a new generation of efforts. As Geneva clearly underscored, the world of minimization and prevention is very large: from the farmer in a developing South Asia nation building a biomass recovery system for animal and crop wastes; to a hamlet in Appalachia trying to reduce costly municipal waste; to a tannery or plating shop in Europe embarking on a wastewater cleansing program; to a large North American industrial complex putting together a closed loop, zero-discharge system.

WMCT-21 defined three major categories of waste minimization and pollution prevention needs and application potentials in global economies: Developing, Mature, and Advanced economies and economic sectors.

The scales of human, technological, and economic resource needed to address the next century's waste minimization needs in these categories will vary considerably. In the first category, basic technology will have to be meshed with often untrained personnel and very scare capital to form a pollution prevention matrix in developing economies and economic sectors.

The next level up for implementing waste minimization and pollution prevention is in mature economies and economic sectors; here, capital for waste minimization and pollution prevention will be in tight supply and technological challenge will be greater, but better trained personnel will be available to address prevention and minimization problems.

In the third category lie advanced economies and economic sectors, where satisfying the pollution prevention requirements of rapidly changing technologies may well absorb the more free flowing available capital, but where a relatively abundant supply of trained specialists will be available to provide continuous innovation and leadership in the field.

EMERGING ECONOMIES

A very dynamic fourth category has come forward since WMCT-21. This is the set of emerging economies resulting from new political arrangements and alliances. Emerging economies are those whose rapid economic growth and sociopolitical evolutions are leading to novel efforts to integrate environmental planning and management into all facets of their economic activities. Democratization in Eastern Europe and the Soviet Union, the addition of countries to the European Community, and efforts of non-European countries to develop enviroeconomic ties with European states have all led to the emerging economy phenomenon.

Emerging economies are neither fully developed nor undeveloped. Their delineations of government and private sector activities are varied, and changing. They consequently will require special attention in government-private sector and transnational cooperation efforts in pollution prevention.

FORMS OF POLLUTION PREVENTION

WMCT-21 and other international efforts have amply documented that pollution prevention takes many forms. And this is an essential consideration for future prevention programs in all economies. Pollution prevention must be defined broadly in terms of total environmental and economic impacts. substituting a plentiful, locally available material for a scarcer one that has to be imported, e.g., can be a pollution prevention measure, as can be reducing waterborne emissions in a production process. Effective land use planning is at least as much of a pollution prevention strategy as is recycling of waste.

Analysis of WMCT-21 and related proceedings indicates that five basic elements are essential for development and execution of national pollution prevention programs. These are:

- Identifying Unique Regional and National Resources
- Defining Unique Environmental Constraints
- Delineating Particular Needs of Major Economic Sectors
- Calculating Pollution Prevention Payback Periods in Defined Sectors
- Embarking on Vigorous Pollution Prevention Training, Information Transfer, and Technology Transfer Programs.

IDENTIFICATION OF UNIQUE REGIONAL AND NATIONAL RESOURCES

The success of pollution prevention depends on the effectiveness of managing resources. And each region and economy has unique resources. Whether energy, materials, land, or labor, these resources must be carefully inventoried to determine their optimal mix. Once this inventory is made, then it is possible to determine the best pollution prevention strategies. Substituting locally available materials for imported ones may be an option. Matching available labor to recycling operations is another. Similarly, development of locally available renewable energy resources--e.g., sun and wind--to supplant nonrenewables presents another set of pollution prevention options.

DEFINING UNIQUE ENVIRONMENTAL CONSTRAINTS

Effective pollution prevention depends on fully understanding the relationship of pollutants to their environment. And every nation and region has a number of unique environmental constraints. In some areas, e.g., land disposal of organic wastes could actually provide benefits through creation of valuable compost, while in others with high water tables and high rainfall land disposal should be avoided at all costs. In urban areas greater recycling and waste exchange opportunities abound than in rural areas. Etc.

DELINEATING PARTICULAR NEEDS OF ECONOMIC SECTORS

Pollution prevention in an economic sector cannot be successful unless there is a comprehensive understanding of the technology and management systems comprising that sector. The theory of pollution prevention can run contrary to practices necessary to implement it. It is therefore necessary to examine all economic activities in terms of their environmental characteristics and the impact of pollution prevention on them.

CALCULATING POLLUTION PREVENTION PAYBACK PERIODS IN DEFINED SECTORS

This is the key to planning pollution prevention. Traditional thinking has dictated that the period of time (payback period) needed to recoup investments in pollution control and prevention is very long--much too long to warrant serious consideration, particularly in a developing economy. Recent experience indicates, however, that this is not the case. When a full lifecycle cost accounting is made, there is a high probability that the payback period may, in fact, be suprisingly short.

Full lifecycle cost accounting includes all costs--short-term and long-term--associated with an economic activity. The costs in medical care, lost productivity, and shortened life-span of drinking water polluted by hazardous waste are as much parts of lifecycle costs as is the price of a piece of machinery or a change in process design that will prevent such pollution.

EMBARKING ON VIGOROUS POLLUTION PREVENTION TRAINING, INFORMATION TRANSFER, AND TECHNOLOGY TRANSFER PROGRAMS

Prevention of pollution and minimizing waste will only be as effective as the human beings who have been trained to plan, design, implement, and monitor pollution prevention systems.

Considerable information now exists on how to put together pollution prevention programs--on the farm and in the factory. The challenge is to develop meaningful programs that will transfer this information, in the form of education and training to the individuals who will be needing it: managers, executives, and laborers. The importance of education and training in this field cannot be underestimated.

The success in efficiently and effectively transferring information and technology, within and between economic sectors, that can enhance pollution prevention efforts will ultimately determine the success of future pollution prevention programs. As WMCT-21 and other forums have made clear, innovative transfer of waste minimization technology will likely be much more important to 21st century efforts to trim global wastes and eliminate future pollution than will be transfer of innovative technologies. Similarly, development of better forms of information transfer, vis a vis developing more information, will be central to these efforts.

LESSONS FROM GENEVA

If there is any one lesson from Geneva--or Budapest or Rabat or Washington or sites of other recent major pollution prevention symposia--it is that pollution prevention programs in the 21st century will rely on the successful cooperation and integration of many perspectives, institutions, disciplines, and economies. They will have many common elements, but their particular form will depend on a number of variables unique to the geographic and economic issues they are addressing.

As we approach the 21st century, pollution prevention will move from an innovative concept to a standard approach in resource and environmental management. As this evolution occurs it will be important to continually re-examine the lessons of Geneva to determine where updating will be needed to speed up the process.

PROTOTYPE EVALUATION INITIATIVES IN A NEW JERSEY VEHICLE MAINTENANCE AND REPAIR FACILITY

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ABSTRACT

In September 1989, the United States Environmental Protection Agency(USEPA) and the New Jersey Department of Environmental Protection(NJDEP) entered into a two(2) year agreement to evaluate pollution prevention prototype technologies in the vehicle maintenance and repair industry. Through a contractor, New Jersey Institute of Technology(NJIT), and in cooperation with the New Jersey Department of Transportation(NJDOT)(the host facility for this study), at least five(5) target technologies have been identified for further evaluation. Each of these technical initiatives will require different evaluations and different types of measurements. The discussion in this paper describes the approach to technical evaluation of these technologies with status and preliminary results.

This paper has been reviewed in accordance with the U.S. Environmental Protection Agency's peer and administrative review policies and approved for presentation and publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

INTRODUCTION

In 1976, Congress passed the Resource Conservation and Recovery Act(RCRA) thus directing the USEPA to develop and implement a program to protect human health and the environment from improper hazardous waste management practices. The USEPA first focused on large companies which generate the largest portion of hazardous waste. Small businesses producing less than 1000 kilograms of hazardous waste per month, known as small quantity generators(SQGs) were exempt from most of these hazardous waste regulations. In 1984, the Hazardous Solid Waste Amendments(HSWAs) to RCRA were signed into law and this established new requirements for SQGs(businesses that generate at least 100 kilograms but less than 1000 kilograms of hazardous waste per month). EPA issued final regulations for these 100 to 1000 kg/mo generators in March 1986 with most requirements effective in September 1986.

In coming years, SQGs may be required to reduce pollutants even further. Currently, Congress is proposing Clean-air legislation that may require smaller industrial sources such as auto body shops to curb chemical emissions. To reduce these emissions, SQG's are exploring new products and processes that are both clean and profitable. Close examination of products and processes are uncovering many opportunities to reduce emissions, to reduce skyrocketing costs of waste disposal and to reduce the liabilities associated with improper disposal.

A two year survey by the USEPA shows that the vehicle maintenance and repair industry leads in numbers of generators(82,530 of 175,000) and highest in quantity of total waste produced (351,500 tons / year) for SQGs. SQGs produce less than one-half of one percent of the hazardous waste produced nationally, however, the sheer number of SQGs pose a threat to human health and the environment. SQGs are discovering that pollution prevention is good business. Recycling, material substitutions, good housekeeping, and replacement of outdated equipment are all sound business decisions that help reduce quantities of hazardous and non-hazardous wastes. In this effort, the USEPA Pollution Prevention Research Branch located in Cincinnati, Ohio has been encouraging new designs, new products, new methods of reducing wastes at the source or through recycling.

Furthermore, the vehicle maintenance and repair industry uses products that may be hazardous or non-hazardous materials. Sometimes, the wastes generated may also be hazardous. For example, mechanics may use products such as rust removers containing strong acids or alkaline solutions, carburetor cleaners containing combustible liquids, used rags containing flammable liquids, paints with flammable solvents or thinners, or change coolants, lube oils, or batteries. For this industry, the USEPA has compiled a list of typical operations of processes which use products that may contain hazardous materials and which probably generate hazardous waste. They are shown in Table 1.

In New Jersey, over 15,000 businesses perform vehicle maintenance and repair functions with environmental problems such as ethylene glycol discharges, VOC and halogenated solvent emissions, spent waste oils/lubricants, freon emissions, oil based lacquers, other paint wastes, and spent acids and caustics. This project between the EPA and the state of New Jersey will attempt to test and evaluate in a typical work place environment examples of prototype technologies which have potential for reduction of wastes at the source or for pollution prevention. It will determine if the technology has a positive effect on reducing wastes and its cost effectiveness.

The NJDOT facility which will be the site of this project houses many of the Department's functions including administrative headquarters, sign making, signal installation and repair, roadway maintenance, and related activities. The specific area within the complex which will be the focus of this project is the vehicle maintenance and repair facility. This facility has responsibility for keeping in effective operating condition a fleet of several thousand cars, trucks, buses, and motorized highway and roadway maintenance equipment.

The first phase of the evaluation will investigate engine antifreeze recycling and reuse, and motor vehicle air conditioning refrigerant recovery and reuse. Other technology evaluations will follow and are discussed in this paper. A base line evaluation of the current waste management techniques, raw materials, and types and volumes of waste generated at the NJDOT is in progress and will be compared to applying equipment, material substitutions, and other techniques to reduce wastes. This paper describes the overall plan to evaluate these technologies.

TABLE 1

TYPICAL VEHICLE MAINTENANCE/REPAIR OPERATIONS WITH MATERIALS USED AND WASTE GENERATED

PROCESS OPERATIONS	TYPICAL MATERIALS USED	WASTES GENERATED
Solution replacement	Antifreeze solution, CFC(R-12), petroleum oil	Hazardous liquid, ozone depleting, combustible liquid
Oil and grease removal	Degreasers(gunk), carburetor cleaners, engine cleaners, solvents, varsol, acids/alkalies	ignitable wastes, spent solvents, combustible solids, waste acid/alkaline solutions
Engine, parts and equipment cleaning	Degreasers(gunk), carburetor cleaners, engine cleaners, solvents, acids/alkalies, cleaning fluids	ignitable wastes, spent solvents, combustible solids, waste acid/alk solutions
Rust removal	naval jelly, strong acids, strong alkalies	waste acids, waste alkalies
Paint preparations	paint thinners, enamel reducers, white spirits	spent solvents, ignitable wastes, paint wastes with heavy metals
Painting	enamels, lacquers, epoxys, alkyds, acrylics, primers	ignitable paint wastes, spent solvents, heavy metals
Spray booth, spray guns, and brush cleaning	paint thinners, enamel reducers, solvents, etc	ignitable paint wastes, heavy metals, spent solvents
Paint removal	solvents, paint thinners, enamel reducers, white spirits	ignitable paint wastes, heavy spent solvents
Used lead acid batteries	car, truck, boat, motorcycle and other vehicle batteries	used lead acid batteries, strong acid/alkalies solutions

POLLUTION PREVENTION PROTOTYPE TECHNOLOGIES

Antifreeze Recycling

Used antifreeze, commonly utilized in coolant/heating systems may be improperly disposed of into community sewage systems and waterways during regular service maintenance of a vehicle. This disposal negatively effects water quality and contributes to the contamination of waterways both of the freshwater and marine environment with organic and inorganic(heavy metals such as lead, arsenic, or zinc) chemical wastes. The idea of recycling antifreeze after appropriate physical and chemical treatment is becoming an attractive alternativa, especially in light of USEPA and various state and environmental agencies imposing fines for improper discharges of used antifreeze to the environment.

The key objective in this task involves the reduction of the quantity of waste generated during the flushing of radiator cooling systems in motor vehicles. The premise is that the aqueous ethylene glycol which is removed from engines does not have to be discarded, rather, it can be regenerated by filtration and addition of specialty chemicals to impart corrosion resistance and then recycled back to an engine.

The system to be evaluated at the NJDOT garage is available through FPPF CHEMICAL COMPANY. Conceptually, the system is relatively simple. It consists of a 100 gallon polyethylene tank, a self-priming pump, a series of three filters, and an additive tank. The process involves removing the coolant from the vehicle into the tank, recirculating it through the filter system to remove suspended particles, checking the pH of the solution and mixing in a chemical additive if the pH is too low, and adding additional ethylene glycol if the freezing point of the solution as estimated by refractometry is too high. Following these steps, the fluid can be returned to the vehicle.

This relatively simple concept presents some interesting chemical questions. There are some industry standards for acceptable performance by antifreeze products. The manufacturer claims that the finished product after filtration and chemical addition meets or exceeds the ASTM-3306 standard for this class of material. We will evaluate claims such as this. Also there are some other determinations which should be made to understand more completely the long term effect of this process. For example, the filtration systems is for the purpose of removing the suspended particles. Presumably, these particles are due to degradation or corrosion of the materials of construction of the cooling system. While the filtering system can remove larger particles, smaller ones will be left in the coolant. In fact, the manufacturer utilizes an additive package to be a dispersant to prevent cooling system deposits. Appropriate tests will be done to determine the effectiveness of the system in these areas. Moreover, we will examine whether there is a limit to the number of times that the coolant can be recycled before there is a sufficient buildup of small particulates that damage the cooling system.

Similarly, we will investigate the necessity of adjustment of pH. It appears that the degradation of antifreeze produces various acids which lower the pH of the coolant towards a pH zone that is corrosive to the metallurgy of the engine. This suggests that the conditions in the cooling system are conducive to the oxidation of the ethylene glycol to some organic acid or acids. The pH can be adjusted by organic salts in the coolant which could either continue to undergo structural change or begin to deposit within the cooling system. Tests will be performed to investigate the increase of organic impurities with the objective of determining if there can be an unlimited cycle of recycling for this type of coolant fluid or if there is a limit to the number of times the material can be reused. Similar concerns can arise from the other chemical additives added to the coolant.

Our testing of this technology will evaluate the following issues:

- Determination of the degree of reduction in the quantity of ethylene glycol discarded compared with the usual practice.
- Determination of the relative cost of this technology compared with current practice.
- Determination at least qualitatively of the contaminants which are contained in the coolant removed from the vehicle prior to reconditioning.
- Any contaminants that may adversely effect the long term operation of the engine need to be quantified, similarly after reconditioning to insure that contaminate level is at acceptable levels.
- Determination of the relative economics of this technology as compared with current practice.

Refrigerant Recovery and Recycling

The pollution prevention goal of this technology involves the prevention of the escape into the atmosphere of air conditioning refrigerants such as Freon during the repair and maintenance of motor vehicles. During current operations, much of the refrigerant typically is released into the air while repairs are made to the system. This technological approach involves venting the refrigerant into a holding tank which also incorporates a recovery process. During the recovery process, refrigerant is drawn through a heat exchange/oil separator. There, all oils and other condensables are removed from the refrigerant prior to its passing into the compressor and back through the heat exchanger where it is condensed into a liquid state for storage. The regenerated refrigerant can then be reintroduced into the cooling system when appropriate repairs or maintenance has been finished.

There are technical considerations when evaluating this technology for its pollution prevention potential. Areas of concern include:

- the capability of capturing all of the refrigerant and of returning all of it back to the vehicle,
- the capability of the recovery/recycle system to produce refrigerant which meets all of the appropriate standards of the industry,

- the recovery and handling of the waste streams of particulates, oil, and water produced as a result of the recovery/recycling process.
- Reliability, system maintenance, and operating costs need to be determined.

In this situation, there has been a industry supported evaluation of the technology for the purpose of providing certification that the reconditioned refrigerant will meet the air conditioning industry standards and will not damage the vehicle equipment. At least one of the possible commercial units for use in this proposed evaluation has been so certified. In our evaluation, consideration of the procedures carried out in this industry test could minimize any duplication of work.

The potential for reduction of atmospheric emissions of CFC 12 using a capture and recycling technology depends upon several concerns. One potential for atmospheric loss of the material lies in the technique used by the mechanic for checking and repairing of the air conditioning system. Reports indicate that in some cases, mechanics may pressurize the system with refrigerant in order to locate a leak, release the refrigerant to the atmosphere, repair the leak, and then repressurize the system. Careful observations and recording of CFC use during maintenance and repair will be required in order to determine this potential.

The economics study will involve some careful observation of the individual techniques and processes used by the mechanic. A side-by-side type comparison of the standard A/C repair procedure and the procedure modified by use of the recovery/recycling equipment will be made. The actual time of the mechanic in carrying out the steps involving the release, transfer, recycling, and refilling of refrigerant in both cases will be recorded. Also, carefully weighing and recording of refrigerant quantities used in each procedure whether it is virgin CFC or recycled material will be done. The costs of any maintenance or replacement part must also be tracked, estimated, and recorded.

Improved Spray Painting Technology

Within the NJDOT maintenance operation is a painting capability. The painting section has responsibility for applying coatings to various kinds of surfaces, ranging from wooden objects to large motor vehicles. From the perspective of pollution prevention, the greater potential for positive benefit would be in the area of spray painting of vehicles. Goals are the reduction of the total amount of paint sprayed resulting in reduced volatile organic emissions, less overspray which needs to be collected and treated as waste, and reduced load on air handling equipment which also results in a waste stream.

The approach proposed in this area is a redesigned spray system which allows application of a paint stream under higher pressure. A manufacturer has expressed interest in this evaluation. The manufacturer indicates that with their system you can get the necessary coverage using less paint and that the painter has better control over the work.

This type of evaluation could be very difficult, because the decision the painter makes about when enough paint has been sprayed onto a surface to provide sufficient coverage is a very subjective decision. The painter must decide that it "looks right." Therefore, some side-by-side comparisons should be done. In this experimental set-up, test surfaces need to be provided and the painter must use both the existing technology and the improved spray technology to coat the surfaces until the coating is visually adequate. At that time, comparison of the amount of paint applied using both systems should be made. Similarly some objective comparison of the coating properties should be made of the surfaces covered with both technologies. This should measure at least the average coating thickness and the uniformity of the coating over the entire surface. There should be a comparison to an industry standard.

This study proposes investigating other issues that include: the ease of clean-up of the equipment, particularly whether or not more solvent needs to be used to clean the paint spray equipment as compared to the existing system. Also, it should determine whether or not existing system represents the current industry standard, and if not then the comparison needs to be done using the industry standard equipment.

Using the improved spray technology, it may also be possible to use coatings with a higher solids content. High solids solvent based coatings are slowly replacing regular solvent based coatings. The major advantage is the ability to comply with the more stringent VOC limitations while using the same paint, equipment, and application techniques. However, high solids coatings usually do not atomize well in conventional air spray equipment due to the higher viscosity and thus higher surface tensions. If this technology can be utilized, then the VOC released to the air will be reduced and this evaluation, if performed, should be done in cooperation with a coating manufacturer.

Another approach should also be investigated. Union Carbide has begun to market a technology under the tradename UNICARB. This technology enables VOC emissions to be reduced 30 to 70 percent in applying high quality coatings by using supercritical carbon dioxide to replace the volatile organic solvent fraction that is used to obtain atomization viscosity. This enables applicators to reduce the VOC emissions while continuing to use high molecular weight polymer systems. Supercritical carbon dioxide produces vigorous atomization that remedies the deficiencies of the airless spray process so that high quality coatings can be applied. The technology claims to be applicable to most spray applied coatings and demonstrated on acrylics, polyesters, alkyds, and commercial paints and lacquers in clear,pigmented and metallic systems. Because the carbon dioxide came initially from the atmosphere, there would be no net increase in the atmospheric carbon dioxide level. This evaluation could be a significant evaluation which may go beyond the use of coating techniques in motor vehicle maintenance and repair situations. If evaluated, this process should be examined in regard to coating ability as a function of quantity of coating applied and volume of organic volatiles released.

Approaches to parts cleaning using aqueous based cleaners and ultrasonic baths

The objective of this pollution prevention technology would be to reduce the quantity of organic solvents used to clean vehicle parts as part of the repair and maintenance activity or to make possible the use of some organic solvent which has reduced toxicity compared to the currently used material.

Even though the facility is using SAFETY-KLEEN cleaning technology, currently there is some organic materials evaporating into the atmosphere from the cleaning containers and as "drag out" with the parts. Therefore, alternative cleaning techniques will have a favorable pollution prevention impact.

The use of ultrasonics can improve the cleaning ability of most solvents by providing a pathway to transmit energy directly to the interface between the surface to be cleaned and the contaminant on the surface. This energy transfer is accomplished by a process called cavitation. Ultrasound waves are transmitted through a medium as an alternating series of high density bands and low density bands. Within the low density bands, localized areas of vacuum are formed. These areas collapse within themselves, or implode, when compression increased immediately after the low density band impinges upon a hard surface. This implosion stage releases energy which can serve the purpose, in this application, of "scrubbing" the surface.

Aqueous based cleaners and ultrasonic bath equipment will be supplied by vendors. Ultrasonic baths may be applied in combination with vapor degreasing apparatus. This approach could be useful for heavily greased parts, among other applications. The aqueous approach is claimed to be most useful for plastics, optics, metal parts, wire, and radiators, among other things. The ultrasonic vapor degreaser approach is claimed to be most useful for applications such as ball and roller bearings, electronic assemblies, mechanical assemblies, and machined parts.

For this proposed evaluation, effectiveness, reliability and relative economics will be compared to current practice. Any additional waste streams produced from the ultrasonic approach should be evaluated. Presumably there could be contaminated liquids, either water based or solvent based. Solvent based materials can be recycled with the equivalency of still bottoms. These materials may be recycled offsite by the solvent recovery service provided by SAFETY-KLEEN.

As in the case of the spray painting evaluation, there is a degree of subjectiveness in this type of evaluation. Generally, in this type of environment, items are cleaned until they look clean or until the operator feels they have been cleaned long enough. To carry out an appropriate evaluation, it will be necessary to develop a standard "dirty" item and then clean it by current technology and all of those to be evaluated. There must also be determined a measurement for "cleanliness" of the item which will provide an indication of the degree of cleaning. The situation becomes complicated when different types of items are cleaned in a given industrial situation. For this NJDOT facility, it may be necessary to determine what parts are most often cleaned and then to identify industry or accepted standards for cleanliness. If none exist, some will need to be devised.

Because part of the potential benefit of this cleaning approach is the reduction of the amount of emissions of volatile organic compounds from cleaning tanks, it will be necessary to take air samples in the vicinity of the operations and to determine the levels of the cleaning solvent in the air. If there is also a possibility of risk reduction by use of a less toxic solvent, then some calculations of relative risk of the two approaches, taking into consideration exposure time, toxicity levels, and exposure levels. The plan to evaluate this technology could be particularly complicated.

Oil Life Extension by laboratory analysis and filtration technology

The goal is to reduce the volume of waste motor oil produced as a result of vehicle maintenance operations. This goal is achieved, in theory, by conducting an oil testing program that establishes the proper oil drain interval. This prevents premature oil changes or increased wear caused by over-extended drain intervals. Oil analysis can provide an early warning of diagnosis of problems before large scale damage occurs. There are several companies that supply this service.

Moreover, this approach may be combined with another operational approach, that is evaluating the effectiveness of bypass filters (sometimes referred to as Dual Filtration) . This bypass filter may be installed on an engine in combination with performing regular lab tests to measure the condition of the oil over time and may further lengthen the time necessary between oil changes.

Standard oil analysis includes:

- analysis of all significant wear metals sometimes up to seventeen elements by spectrography
- viscosity with SAE weight and comparison to new oil
- an infrared scan for determination of soot, additive depletion and contaminants,
- water contamination, glycol contamination
- TBN(total base number) .

Loss of alkalinity, TBN, is due to the formation of acids from sulfur blow-by in the combustion process. When sulfur particles combine with moisture in the crankcase oil, acid is formed which in turn reduces the TBN. Bypass filter manufacturers claim that water is absorbed by these filters and limits the acid buildup in the engine oil. This should be verified in the evaluation.

The question arises whether installation of bypass filters and extended drain intervals will affect the engine warranty. This is a concern and specific acknowledgement will need to be received by engine manufacturers that add-on devices such as bypass filters will not affect warranties.

Also, there should be an independent confirmation that the properties selected by the company as indicative of properly performing oil are valid. Literature search should be done from independent sources to confirm this approach. The bypass filtration system could be evaluated independently from the oil analysis approach such as the effectiveness of the system to remove particulates and other contaminants from the oil. For a vehicle maintenance operation cleanup of other fluids such as transmission fluid or brake fluid might be considered, if practical.

Also, ideally, in an experimental situation, the study should be run long enough with enough vehicles involved to determine whether statistically significant reduction in waste oil generation is achievable. This may require a longer study than is practicable under this program.

Future Plans

The proposed techniques and technologies under this program appear promising for evaluation and the contractor, NJIT, is preparing a more detailed work plan to evaluate two approaches first, that is, anti-freeze recycling and the A/C refrigerant recovery and recycle methods. NJIT is close to completing the draft plan for approval by the EPA.

The spray painting technology will probably require a much different set of evaluation procedures depending on the direction that we select. It will be necessary to define carefully the scope of the project. Different procedures will be required if the focus is only redesigned spray heads and improving the spray painting transfer efficiency than if it were to include high solids coatings formulations or the UNICARB system.

Similarly, the ultra-sonic cleaning technology will be reviewed further. The evaluation and requirements will depend heavily on decisions made regarding what parts cleaning operations are to be used for this study. Further we will review options to determine whether both aqueous-base cleaning and vapor degreasing should be evaluated.

The oil life extension study should be done. It should be determined if a statistically significant study can be carried out. The dual filtration evaluation , evaluated independently or simultaneous, could provide significantly useful information to reduce motor oil generation throughout the U.S.

ACKNOWLEDGEMENT

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SHORT-ROTATION WOODY CROP OPPORTUNITIES TO MITIGATE CARBON DIOXIDE BUILDUP*

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ABSTRACT

Short-rotation woody crops (SRWC) have a significant potential for permanently mitigating carbon dioxide buildup in the atmosphere. Like other forestry options, SRWC can provide a fiber source for many wood products that store carbon for short to long time intervals. However, the greatest benefit can be derived from growing large amounts of woody crops dedicated to substitute for fossil energy resources. To determine how much fossil fuel that SRWC could reasonably displace in the United States requires making a series of assumptions. Assumptions include net SRWC biomass yields per acre (after losses), amount of land available and suitable for SRWC, wood conversion efficiencies to electricity and liquid fuels, the energy substitution properties of various fuels, and the amount of fossil fuel used in the process of growing, harvesting, transporting and converting SRWC biomass. Assuming current production and conversion technologies and a conservative estimate of the viable U.S. land base (35 million acres), SRWC energy could displace 34 to 67 million tons of fossil carbon releases, 3 to 5% of current annual U.S. emissions. The carbon mitigation potential per unit of land is larger with the substitution of SRWC for coal-based electricity production than for the substitution of SRWC-derived ethanol for gasoline. Assuming predicted technology advancements (higher conversion efficiencies and net SRWC biomass yields of 10 dry tons/acre) and a high estimate of the U.S. land base available for SRWC (103 million acres), SRWC energy could displace 272 to 470 million tons of annual fossil fuel carbon releases. The carbon mitigation potential of SRWC-based electricity production would be equivalent to about 7.5% of current global fossil fuel emissions and 35% of current total U.S. fossil fuel emissions.

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INTRODUCTION

Forestry can mitigate carbon dioxide buildup in the atmosphere today through several strategies. These strategies include (1) planting new trees to sequester carbon already in the atmosphere; (2) managing understocked, poor quality and immature forests to increase forest carbon storage; (3) improving forest utilization to maximize carbon storage in forest products; (4) planting trees in urban areas to aid in energy conservation; and (5) using wood as a renewable energy source to displace fossil fuels.

The first three strategies, relating to carbon sequestering or storage, are effective midterm solutions for carbon dioxide mitigation but not permanent solutions unless the new or additional forest production is eventually used as an energy source substituting for fossil fuels. In contrast the latter two strategies offer permanent mechanisms for mitigating buildup of carbon dioxide in the atmosphere by reducing the level of fossil fuel emissions. This paper addresses the last strategy and short-rotation woody crop technology (SRWC) to mitigate atmospheric carbon increases.

SRWC technology involves techniques to promote very rapid juvenile growth rates in selected species achieving maximum mean annual growth rate in 4 to 8 years depending on initial spacing, species and climate. These stands, averaging a production rate of 5-10 tons biomass/acre/year, are harvested at rotation age (4 to 8 years) in winter after leaf fall. Hardwoods are preferred, since they offer the advantage of resprouting from stumps. Some softwoods also benefit from SRWC technology and are more appropriate for some site conditions.

The cycle of growing wood for energy production affects atmospheric carbon emissions in a very different way than does the planting of forests for carbon storage. Forests and SRWC that are never harvested remove and store a fixed maximum amount of atmospheric carbon which varies greatly with forest type. The utilization of forests and SRWC for the production of wood products may raise or lower the maximum amount of carbon stored per acre in a given forest type (Harmon et al. 1990). Forests and SRWC planted and harvested specifically for energy provide some carbon storage in the average inventory of standing trees but, more importantly, provide an essentially permanent carbon mitigation benefit when the wood displaces fossil fuels for energy production. For a simple comparison, consider the example of putting an acre of north central cropland into SRWC production specifically for energy production versus planting the same acre to a longer rotation pine forest strictly for carbon storage. Over the next 100 years the planted forest acre would accumulate aboveground carbon until it had stored about 150 tons of carbon/acre[1] (Birdsey 1990). Unless that forest acre is utilized for wood products or energy products, the maximum benefit to the atmosphere of that acre stops at approximately 150 tons of carbon mitigation (Figure 1). Compare that to an acre of SRWC established specifically for providing an alternative to coal for electric generation. That given acre is assumed to be harvested for energy production once each 6 years thus resulting in the step-like curve shown in Figure 1. Depending on whether present or future production and combustion technologies are assumed, the net benefit to the atmosphere over 100 years of burning SRWC instead of coal for electric generation would be 215 or 487 tons/acre, respectively, of permanent carbon mitigation.[2]

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[1] Soil carbon accretion is not included in this value as such accretion would also occur with SRWC harvested for energy.

But what is the real potential in the United States for SRWC to reduce carbon emissions and provide energy? To answer this question, a series of linked pieces of information are required. They include the amount of feedstock that can be produced, the quantity of electricity or fuel the feedstock can produce, and the quantity of fossil fuel and carbon displaced. The remainder of the paper discusses these.

AMOUNT OF FEEDSTOCK

To determine biomass energy feedstock availability, it is necessary to know the biomass yield per acre of SRWC and the amount of land available and suitable for SRWC. Yields and land availability are addressed separately.

YIELD POTENTIALS

SRWC yields have risen steadily over the past 12 years as SRWC technology has improved. Yields in the range of 4 to 7 dry tons harvestable woody biomass/acre/year are now common in production research trials.[3] If a concerted research effort is maintained, yields of 7 to 13 dry tons/acre/year are believed attainable by the year 2010 on moderate-to-good cropland. To date, the maximum observed experimental yield from a temperate climate SRWC is 19.3 tons/acre/year (Table 1), so the targeted yield goals would seem realistic with adequate research effort (Wright and Ehrenshaft, in press).

TABLE 1. SHORT ROTATION WOODY CROP YIELDS BY REGION; CURRENT AND FUTURE EXPECTED YIELDS FOR OPERATIONAL CONDITIONS AND MAXIMUM OBSERVED VALUES

Region	Yields (dry tons/acre/year) Current	Goal	Maximum observed
Northeast	4	7	7
South/Southeast	4	8	7
Midwest/Lake	5	9	7
Northwest	7	13	19.3
Subtropics	7	13	12.3

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[2] Assumptions and calculations are provided later in the text.

[3] Yield is the standing aboveground woody biomass of the SRWC crop divided by the crop's age, analogous to the forestry term "Mean Annual Increment" or "MAI."

To ensure that SRWC energy feedstock are competitive with other energy sources such as gas, oil, and coal, the U.S. Department of Energy has established a cost goal for delivered SRWC energy feedstock at $2.00/MMBtu ($34/dry ton).[4] This translates to a yield of roughly 7 to 10 dry tons/acre/year on sites with moderate annual land rents ($40 to $60/acre). Current delivered SRWC costs are estimated to be in the range of $2.00 to $3.00/MMBtu ($34 to $51/dry ton) where relatively good cropland can be used, moisture is not limiting, and best available SRWC techniques are practiced[5] (Wright and Ehrenshaft in press). This may, however, represent a relatively small proportion of the available acreage.

SRWC yields are function of genotype, cultural practices, and site quality. Short-rotation species showing the most success under agricultural conditions exhibit a combination of rapid juvenile growth, good stress tolerance, good coppice growth, and disease resistance. Silver maple (Acer saccharinum), sweetgum (*Liquidamber styraciflua*), sycamore (*Platanus occidentalis*), black locust (*Robinia pseudoacacia*), poplars (*Populus* spp. and hybrids), and eucalypts (*Eucalyptus* spp.) have been identified as potential genotypes for SRWC in the U.S. and are currently under SRWC research. Other genera such are also potential candidates for SRWC. Although poplars have dominated research, alternative species are important if SRWC technology is to exploit wetter, drier, or more nutrient-poor sites than poplars would tolerate. Exploitation of poorer sites is essential for expanding the land base suitable for SRWC. New and innovative cultural practices must match species and site conditions to attain future higher yields.

Harvesting and handling technology can affect both net yield (after losses) from the site and feedstock costs. SRWC harvest and transport costs are presently $24/dry ton with several tons/acre being lost in the harvesting and transport process. Lighter, more specialized equipment prototypes may be able to reduce costs by 35%, but substantial engineering research is still needed to accomplish this. Energy needs at this stage of the production process are large and must enter into carbon balance equations.

To obtain high juvenile yields at reasonable costs, research has clearly shown that only land in USDA cropland classes IV or better will be suitable for SRWC. Moderate to good cropland (land classes II and III) that have some erodibility problems would be quite satisfactory from the stand point of production, economic and environmental considerations. Establishment of SRWC crops on cutover forested sites has been tested and is not presently recommended. Results have shown relatively poor growth compared to cropland under cultivation or recently abandoned cropland (Wright et al., in press).

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[4] This goal was based on the assumption that there would be no change in the current prices of fossil fuels. Taxes on fossil-carbon-emitting sources or increases in oil import prices would likely improve the competitiveness of SRWC as a energy source.

[5] These cost figures assume chips are used as the raw feedstock. If whole trees could be burned as has been proposed (Ostlie 1989), the feedstock costs would be significantly less.

LAND AVAILABILITY

Land availability is a function of land quality, agricultural product demands, U.S. agricultural policy, and environmental considerations. Of these four factors the one that can be discussed with most certainty is the first. Within the United States there are about 400 million acres of non-federal land classified as cropland, and roughly 184 million of those acres have suitable, fertility, rainfall and slope characteristics (<8%) for SRWC (USDA/SCS, 1989). About 100 million acres of U.S. land currently in range and pasture is classified as having moderate to good potential for conversion to cropland (USDA/SCS, 1987). Of this "potential" cropland about 50 million acres may be suitable for conversion to SRWC production. All cropland and "potential" cropland in the Great Plains and further west was arbitrarily excluded from this estimate of suitability for SRWC due to presumed moisture and slope limitations. Additionally the use of more drought-adapted herbaceous species would offer additional opportunities to expand the suitable land base. The suitable land base has numerous competing uses and thus cannot necessarily be assumed to be available for SRWC production.

Projections of land needed for current and future food production in the United States have changed considerably in the last decade, allowing the possibility of putting cropland into energy-crop production. In 1982, 153 million acres of the approximately 500 million acres potentially suitable for crop production were not used for that purpose. In addition to the land normally used for range and pasture, varying amounts of productive cropland are idled each year. For any one year during the 1980s, 11 to 78 million acres of productive cropland were idle. To exploit this land base and revitalize U.S. agriculture, a Task Force Report requested by the Secretary of Agriculture (New Farm and Forest Products Task Force, 1987) proposed a national goal of "developing and commercializing within 25 years, an array of new farm and forest products, utilizing at least 150 million acres of productive capacity, to meet market needs representing net new demand for agriculture and forestry production." However agricultural policy changes are needed to put energy crops on "level ground" with other crop programs.

Changes in U.S. farm policies are beginning to occur. In 1985 the Food Security Act incorporated provisions of the type needed to begin establishment of wood energy crops. The Act initiated the Conservation Reserve Program which targeted 40 million acres of highly erodible land for long-term retirement from food crop production. As of 1989, 30 million acres had been set aside under this program. SRWC grown on 9- to 12-year rotations would appear to an ideal crop for some of these lands because the establishment of SRWC accomplishes the goal of reducing soil erosion, yet it is also not as permanent a land-use conversion as conventional forestry.

A low estimate of potential land availability for SRWC was taken to be about 35 million acres or approximately the amount of land eligible for the Conservation Reserve Program in the eastern part of the United States. This includes acres in the following USDA regions: Corn Belt (16.4 million), Lake states (5.7 million), Southeast (2.7 million), Appalachian (4.7 million), Delta States (2.1 million) and the Northeast (3.0 million) (USDA/ERS 1989). A high estimate of potential land availability for SRWC was taken to be about 103 million acres. This includes the 35 million acres previously described, the 50 million acres of "potential" cropland with moderate to good conversion potential in the same regions of the United States, plus about 10% of the current land base in active crop production in the same region (18 million acres). This high estimate is an optimistic but not unreasonable future land base.[6]

The environmental impact of SRWC production technology should be considered in light of current land use. If SRWC are established on cropland, SRWC should result in a 50 to 75% reduction in use of pesticides, herbicides, and fertilizers as well as decreases in erosion. The wildlife impact has not been examined. Since SRWC is rarely economically feasible on anything but cropland or recently abandoned cropland and because of the increasing value of conserving forest ecosystems for multiple uses, it is unlikely that SRWC will displace forests. The overall environmental impact of SRWC production is likely to be benign if not positive, particularly if environmentally suitable sites are selected for conversion to SRWC.

ENERGY PRODUCTION

To determine the amount of energy in the form of electricity or fuel that can be produced from an acre of land or a ton of biomass feedstock, it is necessary to understand the status of conversion technologies, particularly the efficiency of conversion. Conventional wood-to-electricity generating plants (10 to 50 MW_e) have an energy conversion efficiency of about 25%, largely because of high moisture content of the wood feedstock. Ostlie (1989) proposes a whole-tree burner technology which promises a conversion efficiency of 33%. Larson and Williams (1990) and Larson and Svenningsson (1990) have proposed the use of aeroderivitive gas turbines [steam-injected gas turbines (STIG) and intercooled steam-injected gas turbines (ISTIG)] coupled with biomass gasifiers to generate electricity. Efficiencies for STIG and ISTIG, using coal as the feedstock, have been documented at 35.6 and 42.1%, respectively. Conversion efficiencies using biomass as the feedstock have been lower in experiments using currently available gasifiers designed for coal. Because biomass should gasify more easily than coal, Larson and Svenningsson (1990) feel that biomass should have at least as high an overall cycle efficiency as does coal. Using gasifiers specifically designed for biomass will be necessary to obtain maximum conversion efficiency.

It is currently estimated that a dry ton of wood can produce 83 gallons of ethanol, with a conversion process efficiency of 39%. This estimate is based on an ethanol conversion facility model developed at the Solar Energy Research Institute and used for analysis at Oak Ridge National Laboratory. The model shows that an exogenous energy input of 81 kWh of electricity is required in addition to conversion facility energy requirements met by utilizing the unfermented portions of the wood. With improvements in feedstock composition and the conversion process (e.g., enzymes used for hydrolysis of cellulose, fermentation efficiencies) a dry ton of wood could produce 108 gallons of ethanol and also a surplus of 91 kWh of electricity. This would represent a wood-to-ethanol conversion process efficiency of 59%.

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[6] To put this acreage into perspective, soybean is a crop which occupied virtually no U.S. land in the first half of this century and now occupies about 60 million acres. Thus land conversions of the magnitude considered under this scenario have occurred within this century (New Farm and Forest Products Task Force, 1987).

FOSSIL FUEL DISPLACEMENT

The relative amount of electricity produced per dry ton of wood or coal feedstock is a function of the process conversion efficiency (previously discussed) and the relative Btu content of the two feedstocks. The energy content of both wood and coal per unit of delivered weight varies considerably. The estimate used for average energy content of wood is 8500 Btu/dry lb or 17 x 10^6 Btu/dry ton. The average energy content of coal is taken to be about 23.5 x 10^6 Btu/ton as delivered. These values, together with the assumed conversion efficiencies of wood and coal combustion, determine the relative raw Btu levels of each feedstock required to produce the equivalent kWh of electricity. The raw Btu levels of wood and coal required to produce a kWh of electricity are obviously the same if the conversion efficiencies are the same. Once the Btu level of the coal equivalent (to the wood burned) is determined, the calculation of carbon offset (as shown in Figure 1) is straightforward since the carbon content of coal per Btu is nearly constant over a wide range of coal types. That level in coal is 56.24 lb C/MMBtu (24.12 kg C/GJ) if carbon released in the mining and transportation of coal is not considered and 57.48 lb C/MMBtu (24.65 kg C/Gj) if the additional carbon emissions are considered (Marland 1983). We used the latter.

The calculation of fossil fuel displacement in the wood-to-ethanol fuel pathway includes consideration of the relative substitution rates of ethanol for gasoline and consideration of any carbon released in operation of the conversion facility. Liquid fuels derived from biomass do not necessarily substitute for conventional fuels on a one-to-one energy content basis. It is assumed that even though a gallon of ethanol contains only about two-thirds the energy content of a gallon of gasoline, it can be burned more efficiently. Therefore a gallon of ethanol can substitute for 0.8 gallons of gasoline. Much of the energy in the wood used to produce ethanol is needed to provide process energy, and thus is not available to displace gasoline. Consequently it takes about two units of wood energy to displace one unit of energy in gasoline (actually 2.75 and 1.74 wood energy units per gasoline energy unit for present and advanced technologies respectively). This is in contrast to coal displacement where similar amounts of wood energy substitute for coal energy.

NET CARBON BENEFITS

The combustion of wood or ethanol does emit carbon into the atmosphere. However, those emissions are balanced by the carbon taken up by the SRWC energy plantations. However, fossil-carbon inputs are presently required in the production, harvesting, and transportation of SRWC feedstocks. These inputs are relatively small and may be balanced, at least initially, by carbon sequestering occurring in the soil and the unharvested root systems. However, data to document the level of sequestering in soil and roots are not yet available, the sequestering does not continue indefinitely, and the stored carbon might be released if the site was converted back to food crop production. Therefore, for purposes of this analysis all carbon inputs to the production, harvesting, and transportation are assumed to be carbon emissions that reduce the net benefit derived from fossil-fuel displacement. The following discussion will describe the types and levels of carbon inputs and calculate, by conversion technology, the net benefit derived from displacement of fossil-carbon feedstocks with SRWC.

CARBON INPUTS TO SRWC FEEDSTOCK PRODUCTION

To determine the carbon inputs to the production, harvest, and delivery of short-rotation wood feedstocks, a series of assumptions is made for present SRWC technology. First, energy requirements for each operation (site preparation, weed control, fertilizer, pesticides, harvest, transport, and storage) are estimated by fuel type (diesel as a proxy for all petroleum liquids, natural gas, and electricity) and then converted to carbon equivalents. Electricity is assumed to be generated 75% from coal and 25% from nonfossil sources. Average annual yield (after accounting for harvest and storage losses) is 6 dry tons/acre. Harvest occurs on a 6-year cycle, with two coppice harvests, for a stand life of 18 years. Average annual fertilizer applications are nitrogen, 45 lb/acre; phosphorus (as P_2O_5), 13 lb/acre; and potassium (as K_2O), 13 lb/acre. Weed control is used in the first and second years of each harvest cycle. Pesticides are assumed to be applied annually for this calculation, but pest resistant trees and integrated pest management techniques should be developed that will not require nearly as much pesticide use as is assumed here. Harvest, transport, and storage operations are assumed to require 0.92 million Btu/dry ton. For advanced production technology no change in input requirements is assumed, but average annual (after loss) yield is assumed to increase to 10 dry tons/acre.

With present technology, production of an average annual (after loss) yield of 6 dry tons/acre requires per acre inputs of 45.7 gallons of diesel, 2110 cubic feet of natural gas, and 84.3 kWh of electricity, which results in carbon emissions of about 0.22 tons C/acre/year. With advanced technology, production of an average annual (after loss) biomass yield of 10 dry tons/acre requires per acre inputs of 72.0 gallons of diesel, 2110 cubic feet of natural gas, and 84.3 kWh of electricity, which contributes emissions of about 0.31 tons C/acre/year. The difference in diesel usage results from more wood per acre being harvested, transported, and stored.

NET BENEFIT FROM CONVERSION OF WOOD TO ELECTRICITY

The net carbon mitigation benefit obtained by displacing coal with wood in electricity generation increases dramatically with advanced SRWC production and combustion technologies. With present technology a wood-to-electricity efficiency of 25% and a coal-to-electricity efficiency of 34% are assumed. With advanced technology the two conversion efficiencies are assumed to be equal at 42%. These and other important assumptions are listed in Table 2. By substituting wood for coal, about 2.16 and 4.87 tons C/acre/year are offset for present and advanced technologies, respectively. After subtraction of the carbon emissions associated with SRWC production, harvesting and

TABLE 2. ANNUAL CARBON OFFSET PER ACRE BY ELECTRICITY PRODUCED FROM SRWC

Assumptions and Results	Technology Status	
	present	advanced
Biomass Yield (after losses) dry tons/acre/year	6	10
Conversion Efficiencies assumed		
wood-to-electricity (%)	25	42
coal-to-electricity (%)	34	42
Electricity Production (MWh/acre/year)	7.47	20.93
Net carbon emissions (tons/acre/year)*		
Production	0.22	0.31
Conversion	0	0
total carbon emitted	0.22	0.31
Carbon offset by fuel substitution (tons/acre/year)	2.16	4.87
NET CARBON OFFSET (tons/acre/year)	1.94	4.56

*Assumes electricity generated 25% from nonfossil fuel and 75% from coal at the conversion efficiencies for present and advanced as shown in table.

transportation, the net offset of carbon is about 1.94 and 4.56 tons C/acre for present and advanced technology, respectively.

NET BENEFIT FROM CONVERSION OF WOOD TO ETHANOL

Wood is assumed to be converted into ethanol by a simultaneous saccharification and fermentation (SSF) process (Wright 1989). For purposes of this paper this is assumed to include a dilute acid pretreatment, fermentation of xylose, enzymatic hydrolysis of cellulose, and fermentation of glucose. With present technology, conversion of the wood to ethanol requires 0.975 kWh/gallon of additional energy input, which contributes carbon emissions of 0.11 tons C/acre (0.38 lb C/gallon). For each acre of SRWC wood converted to ethanol, total production and conversion carbon emissions amount to about 0.32 tons C (1.30 lb C/gallon) (Table 3).

With anticipated advances in technology, conversion of the wood to ethanol generates a surplus of electricity of 0.84 kWh/gallon, which would have required 0.16 tons C/acre/year to generate. After subtracting out the carbon required for the conversion process, total production and conversion emissions are reduced to about 0.15 tons C/acre (0.28 lb C/gallon) (Table 3).

The net carbon offset by conversion of SRWC to ethanol which is used for gasoline substitution amounts to about 0.97 and 2.65 tons C/acre assuming present and advanced technology respectively (Table 3). Note that the offset of carbon is about twice as high for electricity from SRWC as it is for ethanol from SRWC.

TABLE 3. ANNUAL CARBON OFFSET PER ACRE BY ETHANOL PRODUCED FROM SRWC

Assumptions and Results	Technology Status	
	present	advanced
Biomass yield (after losses) dry tons/acre/year	6	10
Wood-to-ethanol conversion efficiency (%)	39%	59%
Ethanol yield: gallons/dry ton	83.3	108.2
gallons/acre	500	1082
Net carbon emissions (tons/acre/year)[a]		
Production	0.22	0.31
Conversion	0.11	-0.16
Total carbon emitted	0.32	0.15
Carbon offset by fuel substitution (tons/acre/year)	1.29	2.80
NET CARBON OFFSET (tons/acre/year)	0.97[b]	2.65

[a] Assumes electricity generated 25% from nonfossil fuel and 75% from coal at the conversion efficiencies for present and advanced are 34 and 42%.

NATIONAL CARBON AND ENERGY BENEFIT

The potential carbon mitigation and energy supply benefits of SRWC are a function of the acreage dedicated to the production of SRWC crops and the advancement of SRWC and associated energy conversion technologies. To evaluate the U.S. potential two SRWC adoption scenarios are considered.

The first scenario is a "current conditions" scenario. Table 4 gives the assumptions on land base and yield used in this scenario. Under these assumptions, the annual carbon offset by SRWC-based energy production is 2.16 tons C/acre/year if the wood is used to produce electricity and 0.97 tons C/acre/year if the wood is used for ethanol production. Table 4 shows the national carbon mitigation benefits and ethanol or electricity production that would be expected. Even under this fairly conservative scenario, SRWC energy technology could produce a significant fraction of either the U.S. transportation fuel or electricity needs.

The second scenario is a "future" scenario. Under this scenario, the total U.S. carbon benefit would be 272 million tons carbon offset/year assuming ethanol production or 470 million tons carbon offset/year assuming combustion and electricity generation (Table 4). This is about 20 or 35 % of

TABLE 4. SRWC PRODUCTION SCENARIOS—LAND AND YIELD ASSUMPTIONS: CARBON OFFSET, ETHANOL, AND ELECTRICITY GENERATION; COMPARISON TO U.S. FUEL AND ELECTRICITY CONSUMPTION; AND COMPARISON TO U.S. AND GLOBAL CARBON EMISSION FROM FOSSIL FUEL

	SRWC Energy Scenarios			
	Current Ethanol	Current Electricity	Future Ethanol	Future Electricity
Yield (tons/acre/yr)	6	6	10	10
Land base (10^6 acres)	34.6	34.6	103	103
Carbon offset (millions tons C/yr)	34	67	272	470
Ethanol generated (10^9 gallons/yr)	17.3	-	111.4	-
Electricity generated (10^9 MWh)	-	0.26	0.09	2.16
Percent of Current U.S. gasoline consumption	12%	-	79%	-
Percent of U.S. Electric power consumption	-	10%	3%	78%
Percent of U.S. fossil fuel carbon emissions	3%	5%	20%	35%*
Percent of world fossil fuel carbon emissions	0.5%	1.1%	4.4%	7.5%

*This estimate of future carbon offset is greater that the amount of carbon now released by coal-fired electric generation in this country.

the current U.S. fossil fuel carbon emissions and 4.4 or 7.5 % of global fossil fuel carbon emissions[7].

As Table 4 reveals, SRWC has a real and significant potential to offset fossil fuel carbon emissions with a permanent effect. That potential however, will not be realized under current agricultural policy which strongly encourages the status quo. Nor will it be realized without a concerted, stable research effort for the next 20 years. Nonetheless, the potential for SRWC has been well demonstrated and the carbon mitigation benefits are there if we, as a nation, decide to go after them.

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[7] The estimate of future carbon offset resulting from substitution of SRWC for coal in electricity generation is greater than the amount of carbon now released by coal-fired electric generation in this country.

ACKNOWLEDGMENTS

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CORPORATE TRANSITION TO MULTIMEDIA WASTE REDUCTION

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The traditional approach to waste reduction at a major corporation was formulated in the early 1980's as a response to the emerging realities of CERCLA and RCRA requirements. The program targeted reduction of hazardous waste generation, increased recycling of wastes and treatment of remaining residuals. Major progress was achieved over 5 years, but by early 1988 it was apparent that results were diminishing. Public attitudes and expectations, accelerated by SARA 313 reporting, pressed for attention to minimization of all wastes in all media. Over a transitional year, the corporation overhauled its program to achieve these ends and is putting in place program elements to pursue aggressive multi-media goals.

Thank you Mr. Chairman, Ladies and Gentlemen:

As you heard in the opening remarks, the objective of this session is to explore the impediments to industrial approaches to Pollution Prevention, and the solutions we can bring to bear to overcome these impediments. Before I do that, though, I want to make some brief remarks on motivation. That is, why should those of us who represent corporations be interested in devoting resources to Pollution Prevention?

Let's look at some statistics:

- In the last 20 years, world population has increased by 40% or 1.6 billion souls, to 5.3 billion people.
- In this decade, we will add 1 billion more, and by the year 2030 population will double to over ten (10) billion. That's beyond my lifetime, but my new granddaughter will be just forty (40) years old then. Ten (10) billion people will generate a lot of waste.
- The Worldwatch Institute reports that, over the last 20 years, 500 million acres of forest have been lost worldwide -- an area equivalent to the Eastern half of the United States.
- More locally, in St. Louis County where I live we generate six (6) pounds of trash per person per day -- three (3) from industry and three (3) from households. Only a dozen of the 90 suburbs have tried curb-side recycling -- and our landfills have only six (6) years of permitted capacity remaining.

When industry people hear statistics like those, there may be a quiet sigh of relief by some, saying, "well at least those are issues, I don't have to worry about." But in a broader sense we do. Our actions, particularly in leadership roles, in our communities, our states and at the national level will be collectively very important if societal issues are to be successfully addressed.

Let's look at some other statistics:

- We continue to generate 250-300 million annual tons of hazardous waste in the United States, in spite of efforts aimed at reduction. EPA in fact estimates that the total is growing by 7.5% per year.
- The new Toxicity Characteristic under RCRA, when it becomes effective in September, will expand the world of hazardous wastes, increasing it by a factor variously estimated between four (4) and six (6) times. The 250 million ton figure becomes a billion tons per year.
- In April, EPA announced the totals for the Toxic Release Inventory, reported under SARA 313 for 1988. While reported releases were down 9% from 1987, we are still looking at 4.6 billion lbs. per year in the U.S., and, of this, 2.4 billion are releases to air.

So industry does have an issue, and a very important role to play in Pollution Prevention. While we may be convinced that these releases do not constitute a threat to our employees or our communities, the public expectation is clear. We must do all that we can to pursue a goal of no releases, achieve results, and involve our communities in the effort. Ultimately these communities grant to us the right to operate in their midst, but condition that right with an expectation we will not operate at the expense of community health and safety.

Separately, the operations of our plants almost inevitably consume non-renewable resources, so that we have a vital economic interest to reduce our losses of raw materials to wastes or the environment.

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My narrower focus in these remarks, though, is on one corporation's experience in making the transition to a multi-media database.

In the 1982-1988 timeframe, our organized effort on waste reduction focused on hazardous wastes generated by our plants. That program replaced prior efforts and derived from a Waste Management Study done in 1981-82 which concluded several things:

- Past land based management practices were not necessarily protective, as evidenced by our increased involvement as PRPs at Superfund sites.
- Emerging public altitudes cried for reduction and more responsible management of hazardous wastes -- and RCRA was being put into place to drive toward more protective facilities.
- And, finally, the economics available to drive a waste reduction effort had improved, not only in the rising costs of raw materials, but also in the skyrocketing costs for waste treatment and disposal under RCRA.

The stated corporate policy captured the now-familiar hierarchy of management practices, giving greatest preference to source reduction, least to land disposal of treatment residues or other wastes. To minimize our dependence on landfills, two mandates were put into place:

- By January, 1984, all acutely hazardous wastes were incinerated.
- Then, by January, 1986, all incinerable hazardous wastes were in fact incinerated rather than landfilled.

This requirement included many wastes which are non-hazardous under the rules, but which we have elected to manage as hazardous.

Our program also requires that all non-hazardous wastes land disposed in Subtitle D units be reviewed again to further guarantee against future Superfund involvement, an activity that is still progressing. The 1982 policy also mandated the setting of annual reduction goals by plants and divisions, annual review of progress by our manufacturing council and by our corporate Environmental Safety and Health Committee. Waste reduction coordinators were assigned at each plant site, and a newsletter was put in place -- and is still active -- to facilitate a sharing of waste or release reduction ideas.

Very importantly, one effort was unified at the corporate-level. We established a single database, under a single well-documented set of rules, to keep track of our progress. Such a database is vital to any pollution prevention effort. Features included:

- Hazardous and non-hazardous wastes, including wastewaters
- Base year 1982
- 39 U.S. plants
- Multiple reports generated

At this point then, I want to reflect on some of the observations we made in early 1988 when we took a critical look at our effort:

- 97% of our hazardous wastes are waste waters. Under RCRA's mixture rule, the entire stream is a hazardous waste, but there is little financial or environmental incentive to drive reduction of the actual water content of these wastes.
- As we look forward to the effective date of the new Toxicity Characteristic under RCRA, we anticipate that our inventory of hazardous wastes will "jump" by a factor as high as six (6).
- By 1987, we had reduced waste generation by about 50% against the 1982 base. But it was increasingly obvious in 1986 and 1987 that the achievement was increasingly the result of "down sizing", that is, the termination or sale of businesses. It was equally apparent that this trend would not continue.

And so we found ourselves in early 1988 looking at the prospect of flattening performance from our program. At the same time, public expectations were broadening to encompass all wastes generated -- hazardous, non-hazardous and trash. Further, the release of the Toxics Release Inventory for 1987 (and now for 1988) has worked to increase public awareness of chemical releases to the environment -- and public concern that these releases be controlled and eliminated. That concern is multi-media in scope, covering releases to air, water and the land.

Our historic program was not multi-media in scope (no air emissions included) and did not focus crisply on releases to the environment.

PESTICIDE APPLICATION EQUIPMENT RINSE WATER RECYCLING

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ABSTRACT

The Louisiana Department of Agricultural began enforcement of pesticide waste disposal regulations on January 1, 1985. These regulations, which were adopted in 1984, apply to all commercial pesticide applicators and require that they adopt procedures and install facilities to clean the equipment spray system, mixing tanks and pesticide containers without contaminating the soil, water or air.

After evaluation of various pesticide waste disposal techniques, 60% of Louisiana's 180 commercial aerial applicators elected to use waste water recycling to dispose of aircraft spray system wash water.

Waste water recycling involves collecting the aircraft wash water and storing the water in tanks for use as a diluent on future application jobs. Three to five, 250 to 500 gallon tanks are normally used to store waste from various pesticides thus preventing label violations and the possibility of crop damage. Thirty percent of the applicators rinsed the aircraft over the field being treated. Ten percent modified the aircraft or used other waste disposal techniques.

During the past four years, several applicators have been interviewed to determine the cost of constructing and operating the waste water recycling systems as well as information on problems.

Most aerial applicators used a 50 X 50' or 50 X 60' concrete wash area and three to five 250 to 500 gallon tanks. Most systems cost $8,000 to $12,000 with a range of $3,000 to $15,000. Very few problems were reported and there were no reported incidences of crop damage from adding low rates of wash water to the pesticide mix.

INTRODUCTION

During 1981 and 1982, discussions were held between leaders of the Louisiana Agricultural Aviation Association, members of the Louisiana

Cooperative Extension Service (LCES) and the Louisiana Department of Agriculture. These discussions covered techniques required to comply with proposed Louisiana Department of Agriculture pesticide waste disposal regulations (1,2,3).

It was generally agreed that pesticide containers could be converted from pesticide waste to solid waste via triple rinsing (4). Mixing and loading equipment could be washed and the wash water used for dilution. Based on EPA regulations, containment of water used to wash the exterior of the aircraft is not required (5). However, the applicator is ultimately responsible for any soil contamination. Water used to wash the interior of the spray system must be contained and disposed of in an environmentally safe manner.

Current research, state of the art technology and other factors were reviewed. It appeared that commercial aerial applicators had the following options for disposal of pesticide waste:

1. Move off-site for treatment or disposal at a hazardous waste disposal facility.

2. Store on-site.

3. Treat on-site.

4. Recycle.

5. Modify equipment to clean in-flight.

A recent review of current technology indicates that during the past 8 years advances have been made in several areas. However, the cost of collection and transportation for off-site treatment or disposal is still too costly for most commercial aerial applicators. However, this waste disposal technique will be essential in special situations.

On-site storage or treatment will require collection and containment facilities plus the treating equipment. Applicators who plan to use long term storage or treatment will usually be required to obtain a permit from a regulatory agency. Engineering fees, legal fees, insurance or bond costs plus the cost of the facilities will be very expensive. In addition, very few commercial applicators have time to operate such facilities and comply with ever changing regulations.

It was decided that an affordable, environmentally safe system must consider the following factors (1,2,3,6).

1. The commercial aerial applicators must be able to install and operate the waste disposal facilities and still provide quality aerial application at an affordable price.

2. The applicator, pilots and/or loading crew members must be able to operate the system with minimal training.

3. The system must be compatible with normal operations and not require a lot of management time or additional labor.

4. The system must be designed to eliminate the storage of pesticide waste during the off season, thus eliminating the need for permits, additional insurance and record keeping.

5. The system must dispose of the pesticide waste without requiring the transport of waste to a hazardous waste disposal site.

After further research in 1982, it was decided that waste water recycling, rinsing the aircraft over the treated field or modifying the aircraft for cleaning in flight would meet these five objectives. It was felt that rinsing over the field would be feasible for aerial applicators who flew less than 300 hours per year. However, it would be too costly for larger aerial applicators (2).

Engineers from the Louisiana Cooperative Extension Service designed a waste water recycling system for applicators with two to five aircraft. This system was evaluated on a limited scale in 1982 and 1983. Regulations adopted in 1984 by the Louisiana Department of Agriculture legalized the use of this system (1,4). Enforcement of the regulations began on January 1, 1985.

During 1982 - 1986 Louisiana Cooperative Extension Service Specialists and County Agents held annual training meetings in eight locations around the state. The training meetings were usually attended by 20 to 40 aerial applicators. At each of these meetings detailed information and handouts were provided on the regulations as well as techniques for compliance. Ample time was provided for questions. Enforcement officials from the Louisiana Department of Agriculture as well as officers of the Louisiana Agricultural Aviation Association also participated in each training session. These training sessions were very helpful in reducing construction costs for the waste water recycling facilities as well as enhancing compliance with the regulations (2).

During 1985, several commercial aerial applicators built and used waste water recycling systems, others rinsed the aircraft over the treated field and a few applicators modified the aircraft (3).

AIRCRAFT MODIFICATIONS

Agricultural aircraft are equipped with 150 to 600 gallon spray tanks. After the completion of a spray job, 6 to 10 gallons of spray mix will be left in the spray system. Three to five gallons of this mix will be in the bottom of the spray tank and three to five gallons will remain in the spray pump, spray booms, and connecting lines. In addition, residue will remain on the inside walls of the spray tank (9).

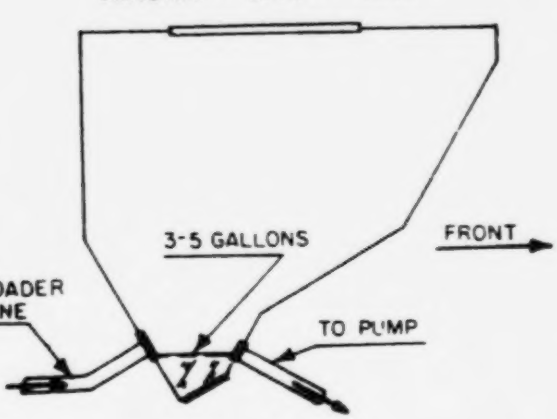

Figure 1. Aircraft spray tank illustrating location of various components and remaining 3 to 5 gallons of spray mix.

As shown in Figure 2, a simple device can be added to the pump intake to remove 2 to 4 gallons of pesticide. This pump intake extension is now commercially available at a reasonable cost. This simple device will reduce pesticide waste by 30 to 40%. In addition, installing a check valve in the loader line will eliminate contamination of this area.

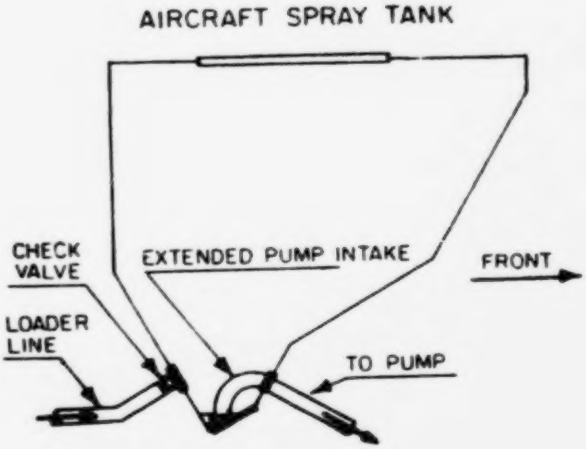

Figure 2. Aircraft spray tank illustrating installation of pump intake extension and loader line check valve.

Commercial firms now offer on-board washout systems. These systems consist of a 15 to 20 gallon reservoir, a pump with a D.C. motor and a cluster of nozzles inside the spray tank. The reservoir can be a tank or collapsible bag inside the spray tank. The reservoir can be filled with clean water for the last load of a spray job. After exhausting the pesticide the sides of the spray tank can be washed with 8 to 10 gallons of water. This water is then sprayed onto the treated area. the sides of the spray tank are then washed a second time with 8 to 10 gallons of water which is then sprayed on the treated area. If required, the aircraft can return to the loading area where the washout reservoir is refilled and 20 to 30 gallons of water added to the spray tank. This water is then sprayed on the previously treated area to thoroughly clean the entire spray system.

On-board purging or wash-out systems eliminate the need for costly containment or recycling systems. In addition, these systems are very convenient for use on remote sites.

WASTE WATER RECYCLING SYSTEM

The waste water recycling system designed by the LCES consists of a 50 X 50' to 50 X 60' wash area, a sump to contain the waste water, a pump, connecting lines and 3 to 5 holding tanks with a capacity of 250 to 500 gallons each (7).

Cost varied from $1.50 to $2.50 per square foot depending on the site preparation required, fill material required, thickness of concrete, type of underliner, amount of steel used for reinforcement and other factors. As expected, applicators who did most or all of their own construction had the lowest cost (9). Specifications for the wash area, sump and tanks are contained in the Louisiana Department of Agriculture pesticide waste disposal regulations (4,7).

Louisiana regulations require elevation of the pesticide waste storage tanks so leaks will be readily apparent. Also, a secondary containment structure capable of holding 110% of the volume of the largest tank is normally required (4).

The number and size of tanks depends on the size of the operation and the variety of pesticides used. Under Louisiana conditions, most applicators will have three to five tanks with a capacity of 250 to 500 gallons each. The pesticide waste water must be segregated and stored in separate tanks to avoid label violations and the possibility of crop damage.

Tank cost varied depending on tank size, type of tank, and whether new or used. A typical waste water recycling system is shown in Figure 3.

Data for construction cost is shown in Table 1 and data for operating cost is shown in Table 2. This data is based on a system for 3 to 5 aircraft with each aircraft flying 400 to 700 hours per year (9).

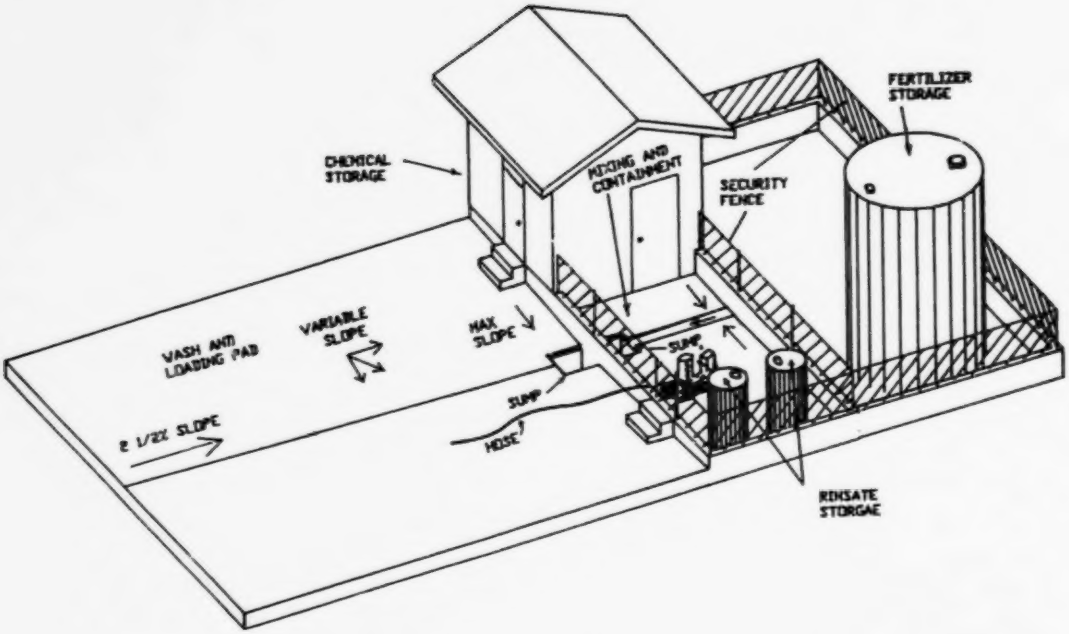

Figure 3. Typical waste water recycling system. Number and size of wash water or rinsate storage tanks can be varied as required.

TABLE 1. CONSTRUCTION COST FOR WASTE WATER RECYCLING SYSTEMS

50 X 60' Concrete Wash Area	$ 6,000
Five Tanks (500 Gallons Each)	3,000
Plumbing and Electrical	1,000
Pump (2 HP, 2" Capacity)	1,000
Labor	1,500
TOTAL	$ 12,500
Range $3,000 - $15,000	

TABLE 2. ANNUAL OPERATING COST FOR WASTE WATER RECYCLING SYSTEMS

Depreciation (10 year life)	$ 1,250
Interest on Investment (12% Interest)	800
Maintenance	600
Labor (75 Hours @ $8.00)	600
TOTAL	$ 3,250

The concrete wash area can be used to mix and load pesticides as well as service the aircraft. Therefore, a portion of these costs should be attributed to other phases of the operation.

OPERATING PROCEDURES

The applicator must first decide what pesticide waste will be stored in each tank. Waste from various pesticides must be segregated to avoid label violations and compatibility problems. Each tank should be labeled so that all pilots and loading crew members will always know what is stored in each tank. This will reduce the possibility of errors in utilizing the waste as a dilution agent on future application jobs. An example of how the tanks can be utilized is shown in Table 3. The type waste stored in the various tanks will vary from area to area within Louisiana as well as from year to year.

In this example, the pesticide waste generated from cleaning the aircraft after applying soybean pre-emerge herbicides will be stored in tank number one. Most soybean pre-emerge herbicides will be applied in April - May. Therefore, this tank can be cleaned and utilized to store soybean fungicide and insecticide waste during July - September.

TABLE 3. EXAMPLE OF WASTE WATER CONTAINMENT TANK UTILIZATION

TANK NO.	TANK SIZE	TYPE OF WASTE WATER	
		EARLY SEASON	LATE SEASON
1	250 Gal.	Soybean Pre-emerge Herbicides	Soybean Fungicides and Insecticides
2	400 Gal.	Soybean Post-emerge Herbicides	Soybean Defoliants
3	500 Gal.	Cotton Pre-emerge Herbicides	Cotton Insecticides
4	500 Gal.	Cotton Post-emerge Herbicides	Cotton Defoliants
5	300 Gal.	Rice Herbicides	Rice Fungicides and Insecticides

NOTE: The number and size of tanks can be varied to meet the needs of the applicator. Pesticide waste water from post-emerge herbicides can be applied with pre-emerge herbicides. However, waste from pre-emerge herbicides should never be applied with post-emerge herbicides.

Waste water should be recycled by mixing one part pesticide waste water with four parts fresh water for dilution of the pesticide.

The second step in utilizing the waste water recycling system requires that the applicator decide whether or not to wash the aircraft between spray jobs. As an example, when changing from soybean fungicides to soybean post-emerge herbicides to soybean insecticides it will not be necessary to wash the aircraft. All three types of pesticides are labeled for application on soybeans. Therefore, phytotoxicity and label violations will not be a problem.

The applicator should use his experience, judgement and knowledge of various pesticides to schedule application jobs and aircraft washing to minimize the volume of pesticide waste.

The applicator should never store pesticide waste unless he knows of a future job where this waste can be added to the pesticide mixture and promptly applied. Ideally, this waste should be used within two to three weeks.

The aircraft should be rinsed over the field being treated if the applicator is uncertain about how or when he can recycle the waste. This is especially true if the pesticide is seldom used in his operation.

Rinsing the aircraft over the treated field can be costly and time consuming. However, this may not be as costly as transporting the waste to an approved disposal site or other types of on-site treatment.

COLLECTION PROCEDURES

The applicator can use two techniques to collect the pesticide waste water when washing the aircraft spray system. The first technique involves dumping the waste on the concrete wash area. The second technique allows pumping the pesticide waste and wash water directly from the aircraft.

If the first technique is used, the wash area should be washed to remove all soil particles and other debris. The aircraft is then taxied onto the concrete wash area. After dumping the waste pesticide, the aircraft spray system is thoroughly washed. This includes washing the spray tank and purging the spray booms, spray pump and all connecting lines.

The waste pesticide, spray system wash water and water used to again wash the concrete wash area drains into a sump located adjacent to the wash area.

The waste pesticide and wash water is then filtered to remove trash and pumped into the storage tank designated for storage of this type pesticide waste.

The second technique requires connecting hoses with appropriate adopters to the outer end of each spray boom or a fitting and valve installed on the bottom of the aircraft spray tank. The spray system is washed as previously described. The waste pesticide and wash water is then pumped into the storage tank.

Use of this technique is recommended because it reduces contamination problems that could cause nozzle plugging as well as contamination with other pesticides.

The use of flexible hoses to transfer the waste from the aircraft to the containment tanks is recommended. After cleaning the aircraft, the hose is always flushed with clean water to remove all pesticide residue. This practice eliminates cross contamination and possible label violations as well as crop damage. In addition, physically connecting the hose to the proper storage tanks assures that the wash water will be stored in the proper tank. This practice also holds true when removing pesticide waste water from the tanks.

Applicators report that it requires at least 80 to 100 gallons of water to thoroughly wash the aircraft spray system (9). The aircraft spray system will normally contain 4 to 7 gallons of field strength pesticide waste. Therefore, the pesticide waste water stored in the containment tanks will have a pesticide concentration of less than 10% of normal field strength (9).

One part pesticide waste water should be mixed with four parts fresh water when using the waste for pesticide dilution. The resulting spray mixture will contain a maximum of 2% additional pesticide. This low level of additional pesticide reduces the probability of label violations, illegal residue or crop damage should an error be made in mixing or loading.

SUMMARY

Interviews with Louisiana aerial applicators after the completion of the 1989 spray season indicates that problems have been minimal. Pesticide waste water can be disposed of by rinsing the aircraft over the treated field or recycling. There were no reports of illegal crop residues or crop damage caused by recycling of pesticide waste water (3).

Aerial applicators flying less than 300 hours per year felt that rinsing the aircraft over the field costs less than constructing pesticide waste water recycling systems. Larger applicators felt that the use of a recycling system consisting of three to five 250 to 500 gallon tanks and a 50 X 50' to 50 X 60' concrete wash area was a good investment. Construction cost ranged from \$3,000 - \$15,000 with most systems costing \$8,000 - \$12,000. Annual operating cost was about \$3,000 - \$4,000 for an applicator with three to five aircraft with each aircraft flying 400 to 700 hours per year.

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POLLUTION PREVENTION IN TEXTILE WET PROCESSING
AN APPROACH AND CASE STUDIES

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Abstract

INTRODUCTION

Environmental concerns of the textile wet processing industry, once limited to effluent discharge requirements, have expanded to include pretreatment specifications, aquatic toxicity, color, air emissions, and restricted landfill availability. Additionaly, a more aware and environmentally sensitive public has even forced textile public relations into the environmental arena.

Ever-rising costs of potable, process-quality water, coupled with wastewater treatment, has put to death the theory that "dilution is the solution to pollution." Plant management has finally come to the realization that there is often a direct relationship between pollution and profits. Increased pollution, resulting from wasteful handling of dyestuffs, chemicals, commodities, excessive water use, improper inventory control, and lax maintenance programs, produces higher wastewater treatment cost, increased chemical cost, higher water cost, and ultimately leads to reduced profit margins.

METHODS

Taking a "fresh look" at a facility, its operating procedures, the products used in processing, and the waste produced, can lead to a combination of approaches resulting in waste reduction. A "fresh look" is accomplished by someone with no preconceived ideas or answers in hand--someone who will ask why without the fear of repercussions or ridicule. A plant walk-through approach will be outlined with areas to pinpoint for closer examination.

This action, followed by a detailed review of the material safety data sheet information, inventory QA/QC practices and processes, can lead to explanations for aquatic toxicity problems and other non-compliance problems. Information on environmentally harmful dyestuffs, commodities and chemicals, with possible substitutes, will be presented along with explanations of process modifications which have been successful in the past.

RESULTS AND CONCLUSIONS

Actual case summaries of successful approaches used by North Carolina textile mills, ranging from simple inventory control to equipment modification to equipment replacement, will be used to demonstrate that pollution prevention does pay. It pays in dollars for industry and in the environment for the public.

BASIC APPROACH - WASTE AUDIT

As is the case with most manufacturing facilites, waste in a textile wet processing facility is found in four basic arenas--waterborne, airborne, hazardous and solid. Each waste stream comes with its own unique management problems; however, the initial steps taken to deal with these wastes should be the same--elimination and reduction. The best first step toward proper waste management is a waste audit.

A waste audit not only identifies and quantifies waste streams, but it further identifies the practices, procedures and processes which result in waste generation. Further, it provides the basis for the collection and evaluation of technical and economic data necessary to select appropriate waste reduction and management techniques (1). Using six basic steps beginning with 1) developing a written corporate waste reduction policy and progressing through, 2) audit team selection, to 3) gathering of all available background data, to 4) developing a plant flow diagram and conducting an in-plant survey to, 5) performing a mass materials balance for each process, and finally to, 6) the technical and economic evaluation of waste reduction alternatives, the waste audit approach can become a simple tool used to help construct the waste reduction plan (2).

As is apparent by the first step in the waste audit, the development of a waste reduction plan must begin with true and real corporate commitment which is easily identified and understood by all employees. Employees will rise to or fall to whatever level is expected of them; therefore it is essential that the commitment to waste reduction is made apparent and the goals of expectation be set at achievable levels. Employees are the first line of defense against waste generation; therefore they are the key to waste reduction. Proper education of employees as to what a waste is, where it comes from, the effect it has on the environment, the effect it has on profitability and ultimately their job stability, can help assure that the waste reduction alternatives adopted in step six will be properly implemented and maintained.

APPLICATION TO TEXTILES

Traditional areas of concern when dealing with textile effluents have been BOD, COD, TSS and oils. These parameters, though still important, have recently been overshadowed by such issues as aquatic toxicity, color, and metals and chloride effluent limitations.

The best approach to dealing with all these concerns is the examination and evaluation of all products used in a facility. By insisting that chemical and dye vendors provide information on BOD and COD as well as other essential data found on the Material Safety Data Sheets (MSDS), educated decisions can be made regarding appropriate substitutions which can reduce effluent pollutant loadings. Additionally prescreening of all products used in the facility and testing of incoming ingredients can provide valuable information on pollutants which may be introduced indirectly (5).

CHEMICAL CONSERVATION

Many textile mills use excessive and even unnecessary chemicals. Often chemicals are added to a dye recipe to counteract a negative side effect of another ingredient instead of finding a substitute for the offending chemical. This approach can result in a series of unnecessary chemical additions which negatively affects effluent quality and processing costs (5).

All processing recipes should be reviewed and reduced to their original base state. If a problem arises from the base state then chemical substitutions should be considered in lieu of chemical additions.

Excess chemical usage also results from lack of precise measurement techniques. These techniques range from the "scoop" method of chemical addition to lack of specifics on filling of machines with water, finishes or other mixtures. By providing specific instructions and metering/measurement equipment, both chemical and water usage can be reduced.

Another simple approach is to use available data to formulate only the quantities of finishes needed. If data is not available, then a data base should be established which will eliminate excess quantities from been washed down the drain.

METALS LOADINGS

When attempting to isolate and reduce metals loadings in textile effluents, all aspects of plant operation must be examined because metals sources can be found from incoming water to maintenance chemicals.

Water Supplies

Water supplies, in particular well water, can contain elevated metals levels; therefor, incoming water should be tested to determine the base level from which to work. Additionally, seasonal water evaluation is recommended as water treatment is often adjusted seasonaly.

Incoming water has in some cases contained metals loading exceeding required effluent limits. It is not uncommon to find significant levels (>1ppm) of zinc, copper, and iron in public water supplies (4).

Incoming Fibers

Incoming fibers often contain metals, both naturally occurring and added. Natural fibers such as cotton adsorb metals from the environment during growth. The addition of antistatic and antifungal treatments often result in manmade (and natural) fibers arriving with elevated metals loadings. Other sources of metals contamination of incoming fibers include warp sizes and machinery oils as well as polymerization catalysts in manmade fibers (4).

Oxidation/Reducing Agents and After Treatments

Oxidizing/reducing agents and after treatments have traditionally contained metals. Although the use of dichromate oxidizers has basically been replaced with periodate, bromate and peroxide oxidizers, they are still used in many laboratory cleaning chemicals. Examination of all laboratory testing and cleaning chemicals is therefor recommended. If the use of dichromate or other metal-bearing solution is to continue in the laboratory, an alternate method of disposal should be established.

Examination of reducing agents may identify metal-bearing solutions which can be replaced with nonmetal-bearing treatments. An example would be the use of sodium hydrosulfite in lieu of zinc stabilized sulfoxylate (5). Copper sulfate is still being used as an aftertreatment for direct dyes, but is being replaced by organic resinous fixatives. This eliminates the metal contributions, but increases the BOD and nitrogen loadings in the effluent. The use of epsom salts as an antimigrant until the application of a fixative from a continuous resin finish formulation can reduce the BOD, nitrogen and metals loadings (5).

Dyes

Metals can be expected to occur in certain dye classes. This data has been published by the American Dyestuff Manufacturers

Institute (5). Most of these dyes are green or blue and usually occur in the 74000 series of chemical constitutions which are phthalocyanine dyes and pigments (4). The first and most obvious approach to this source is the total replacement of the metalized dye; the second approach is to use a metalized dye only when specific contracts mandate their useage; the third approach is the replacement of only a portion of the metalized dye thereby reducing but not eliminating the metals; and, the final approach is to assure complete exhaustion of the dye onto the fabric. This can be accomplished by adjusting time, pH, temperature, salt concentration, fixatives and other parameters.

Finishes and Repair Procedures

Tin, antimony and zinc can be found in water repellant, flame retardant, antifungal and antiodor finishes. Reduction in metals from these sources involves the formulation of only the volume needed and collection and storage of excess for future use.

Repair procedures may involve the use of stripping ingredients such as zinc sulfoxylate-formaldehyde, permangenate or dichromate. An evaluation as to the need of these activities and the ingredients used should be conducted.

Miscellaneous/Less Obvious Sources

Metals contamination of effluents can also be traced to less obvious sources. Examples include zinc contamination of salts used in processing, metal-containing biocides used in cooling towers and air-wash systems, and photographic processing activites used for screen making. Additional sources include herbacides, pesticides, maintenance chemicals, lubricating oils and needle oils. A review of MSDS information should provide data on the type and quantity of metal contained in each product.

AQUATIC TOXICITY

With the enforcement of EPA regulations regarding the aquatic toxicity of effluents, the textile industry has an entirely new environmental problem to address. Determining the cause of an aquatically toxic effluent can be extremely difficult as it may be a result of a single ingredient, a combination of ingredients, or other existing conditions. Further complicating the problem is the fact that toxicity problems sometimes appear and disappear for no apparent reason.

Metals

Compliance with effluent limits has lulled many textile facilities into a false sense of security. Many textile mills are in full complianace with discharge permits with exception of toxicity. Compliance with metals limits does not necessarily translate to compliance with toxicity limits. For this reason it is important to eliminate the use of as many metalized ingredients as possible. If toxicity is sporadic then examination of cleaning or maintenance routines that occur infrequently is in order.

Salt

The traditional approach to aquatic toxicity problems in textile mills has been a reduction in salt usage. It is easily understood that freshwater organisms cannot survive in a saltwater discharge. More often than not, salt removal has not resulted in toxicity compliance. This is not intended to downplay the seriousness of over use of salt in the textile industry or the problems faced by mills in trying to comply with chloride discharge limits of 230 mg/l or less. It is intended to point out the reality that there are many other contributors to aquatic toxicity and the seriousness of this issue. Elimination of salt usage should therefore not be expected to immediately solve toxicity noncompliance problems.

Surfactants

Surfactants, detergents, emulsifiers and dispersants frequently contribute to the aquatic toxicity faced by textile mills. The action of a surfactant is to lower interfacial tension of water and other materials at phase boundaries. This helps to insure even, thorough and rapid wetting and penetration of processing solutions into the textile substrates. This unfortunately is the same feature that causes toxicity to aquatic life (4).

There is ongoing research into the relative toxicities of surfactants. Results indicate that there is considerable variance in toxicities even between similar types of surfactants. There seems to be a general trend that, all other factors being equal, surfactants which contain more hydrophyllic groups (higher HLB) have lower toxicity. Another approach is to consider the biodegradability of the surfactant. A surfactant with a moderate-to-low toxicity that will not degrade will produce a more toxic waste stream that a surfactant with a higher toxicity that will easily degrade (4).

One approach taken for toxicity reduction in wastewater is to substitute LAE for ethyoxylated octyl or nonyl pnenol(AP) wherever possible. Though reducing toxicity, this substitution can increase BOD (4).

Some rules of thumb to remember in considering toxicity and degradability of surfactants:

- -the more linear the molecule, the more degradable the molecule
- -branched hydrophobes are less degradable than linear and aromatic are the least degradable
- -BOD:COD ratios in a textile mill usually range from 2.5:1 to 5:1. A very high ratio, >5:1, indicated poor biodegradability (4).

Quaternary Amine Compounds

Quaternary Amine Compounds, "quats" are found in a variety of uses throughout textile wet processing. One major use is as a softener or finish for fleece products. Although this treatment does provide a high quality product, it can be the cause or a major cause of aquatic toxicity noncompliance.

The use of "quats" can be determined once again by a review of MSDS information. This compound, if an ingredient in a product, will be listed on the MSDS. A close review should be conducted to determine the need of any product containing a quaternary amine compound. If the use is necessary, then some form of waste stream segregation or other method of catching the waste should be investigated.

Solvents

Typical solvent emulsions include use as scouring agents or dye carriers for synthetic fibers. Typically these materials exhaust into the fiber and are later driven off as airborne waste during drying. Solvent emulsions can however become a part of the wastewater stream through spills, leaks, drum washing activities, batch chemical dumps and poor housekeeping.

Objectionable chlorinated materials used in scouring can be replaced with non-chlorinated materials such as xylene for chlorotoluene. Solvents use in non-aqueous applications such as machine cleaners or laboratory uses can be recovered for reuse or pickup and disposal. Solvents should be segregated by type and should not be disposed of via sanitary sewer (4).

CASE SUMMARIES

PROCESS MODIFICATION

The J. P. Stevens Co., Lincolnton, North Carolina, used biocides in the air washer in an attempt to control algae growth.

The basic "blow down" and periodic cleaning from this system was discharged to a small stream. Following stream analysis, which indicated the discharge to be aquatically toxic, the North Carolina Division of Environmental Management revoked the discharge permit. When the city refused to allow the discharge into the sewer system, J. P. Stevens was faced with a serious problem. The air wash system was necessary for the carding, spinning and winding operations and some form of disinfection was required to control algae growth within the system.

After a review of available options, a decision was reached to install an ultraviolet disinfection system on the air wash system. This closed-loop system would solve two problems. It would eliminate the discharge and the use of the biocides.

The system installed, provided by Hydro Systems, Inc., was capable of disinfecting 100 gpm of air washer cooling water. As can be seen below, the payback period was less than two years, after which the company can show an annual cost savings of $2,578 (6).

Capital cost....................	$4,560
Annual Operating Cost...........	$ 872
Annual Biocide Cost.............	$3,450
Difference in Annual Costs......	$2,578

Pay Back Period = 1.77 yr.

CHEMICAL SUBSTITUTION

United Piece Dye Works located in Edenton, North Carolina was faced with reducing the phosphorous in their effluent from 7.7 mg/l to 1 mg/l. Instead of building an expensive treatment system, a decision was reached to approach the problem through chemical substitution. Through a detailed analysis of prodution processes, process chemistry, and the chemicals being used, sources of phosphorous were identified. Chemical susbstitution and process modifcations were made to allow for the use of non-phosphate chemicals. Examples include the reduction in use of hexametaphosphorous and the elimination of the use of phosphoric acid. The results are environmental compliance with no capital expenditures (7).

INVENTORY CONTROL

West Point Pepperell in Robeson County in North Carolina undertook a program to evaluate all chemicals, dyes and commodities used within their facility. A committee of employees was set up and evaluations took place based on safety, fire potential and environmental hazard of each chemical. Areas such as biodegradability, metal content and toxicity were considered. By evaluating all chemicals and eliminating those not necessary, and finding substitutes for those of a hazardous nature, West Point Pepperell has greatly reduced their waste management cost as well as reducing chemical costs. Some examples of changes made include the substitution of a water-based cleaner for an organic solvent cleaner, the rejection of dicholorbenzine dyes due to the benzine base and the rejection of a chloride catalyst for resins due to its association with bis-(cholormethyl) ether.

The committee continues its work by evaluating all chemicals proposed for use in the facility and by working with vendors to assure that the chemicals specified are environmentally sound (7).

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THE BUSINESS COUNCIL OF ALABAMA
WASTE MINIMIZATION INITIATIVE

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First of all, I want to thank you for the opportunity to speak and share some information about the Business Council of Alabama and its member interest and efforts in the area of waste minimization. I appreciate the Environmental Protection Agency (EPA) including representatives from Alabama businesses in the information sharing process and I hope to add to the information already provided by the other speakers from Alabama.

The Business Council of Alabama (BCA) is an organization which was established in 1985 through the merger of the Associated Industries of Alabama (AIA) and the State Chambers of Commerce. The organization's function is to present business and industry views and concerns to governmental officials on the State and Federal levels to promote the business climate in Alabama. BCA is composed of approximately 2200 business and industry members located throughout Alabama in virtually every type commercial operation from small to large scales. These members represent over 60 standard industrial codes.

BCA has developed standing committees to follow State, Federal, and, on occasion, local initiatives in several areas, such as environmental, industrial relations, governmental affairs, and health benefits, and advise the membership of any potential impact(s). The committees, such as the Environmental Resources Committee, may form subcommittees or a task force in order to expedite review and reporting on issues. The potential resources of the BCA membership is unlimited in terms of technical knowledge and information available by industry type.

It was a BCA task force, composed of eighteen BCA member companies, that began working with Mr. Dan Cooper of the Alabama Department of Environmental Management (ADEM) in 1988 to address pollution prevention and waste minimization issues. We felt the time was right to implement a program to educate the public and make a concerted effort to minimize waste at all levels of our society. There have been numerous news stories of mismanaged wastes and we would like to show that reputable companies can do the job right.

The first step in our plan was to have the Governor call together the top corporate executives from around the State and urge them to participate in a voluntary effort to minimize waste generation. This came to fruition on November 17, 1988, when approximately 100 executives came together in Birmingham to hear from the Governor, the Region IV EPA Administrator, the ADEM Director, and an executive from the Ciba-Geigy Corporation as they discussed the problems, the needs, and the challenges which lay ahead in the area of wastes and their disposal. The Ciba-Geigy representative gave an excellent presentation on the efforts of their Corporation to reduce waste by going to process changes, raw material changes, etc.

The BCA task force next recommended that the original committee be expanded to include other groups, such as education, government, environmental, and the general public. On May 31, 1989, such a group came together for the first time, known as the Alabama Waste Minimization Advisory Committee. The Committee consisted of the Alabama Department of Education, the Alabama Department of Economic and Community Affairs, the Association of County Commissioners, the League of Municipalities, the Business Council of Alabama, the Alabama Chemical Association, and the Alabama Department of Environmental Management. Two representatives from the public at large were also included. The goal statement for this group included the development of voluntary programs for the minimization of wastes generated in Alabama and the dissemination of appropriate information to affected groups. Activities thus far have included working with the Department of Education to include waste minimization in school curriculums and the development of a speaker's bureau and program to provide talks at civic club meetings, etc., on minimization. As a group, we have also provided written comments on proposed State legislation on recycling.

Besides serving on the advisory committee, BCA members have worked with the Hazardous Material Management And Resource Recovery Program (HAMMARR) at the University of Alabama and have invited the HAMMARR Program Directors to make presentations to BCA's members on several occasions regarding the programs available for industry and the possibility of having joint seminars around the State on waste minimization and regulatory compliance. We have taken an active part in, as a co-sponsor for the Auburn University Engineering Extension Service, an annual conference on hazardous waste and waste minimization, providing speakers from our membership to address case studies and other technical information.

Why do we want to make the effort to encourage waste reduction? Let's look at a slide that shows what industry faces in making waste management decisions today and then let's look at why we want to make a more concerted effort.

It is to industries' advantage to look for ways to minimize their solid and hazardous wastes, as well as any other potential for waste at their facility, such as in water use. When you consider that most households can place their solid waste at the curb and have it picked up and worry no more and yet industry must provide for treatment and/or disposal, either on-site or off-site at ofttimes considerable expense, common sense prompts the question, **"Why pay if you can eliminate or reduce?"** This represents both sound waste management and good financial sense. It makes sense to allow groups such as the Bicentennial Volunteers, Incorporated (BVI), or Shoals, Inc., groups of retired engineers and scientists working in Tennessee and Alabama to go through facilities and perform non-regulatory waste minimization assessments, because those of us who work in the same production environment daily may overlook the obvious while an experienced newcomer in the same environment may identify a major savings.

We (BCA) held our first Environmental Conference in February of this year in Montgomery and had representatives from the Alabama Department of Environmental Management and Region IV EPA discuss their programs. We provided case studies and research literature from the Waste Reduction Resource Center, the Chemical Manufacturers Association, and EPA to members and there was a lot of information sharing between members, which was the purpose of the meeting. We had over ninety participants at this first conference with a lot of interest shown in continuing the efforts within BCA. We also provide information on our programs and of available information through the monthly BCA newsletter which goes to all the member companies.

This year we plan to provide, within the BCA membership, roundtable discussions at various locations in the State for environmental problems and issues which members may share with others. Many people tend to think they are the only company with a particular problem, but in sharing information we feel a teamwork will develop further to solve some of these problems. We see having a cross-section of industries at each of the meetings should provide for more information being shared. We are also requesting that industries write up case summaries of minimization efforts in the same format of those in literature from the Waste Reduction Resource Center to provide our members with guidance and contacts for their own particular facility efforts.

I work for a utility and we encounter problems that other companies also have and I will go through a few slides and address some of the issues. There have been major savings from doing simple things like segregating waste streams better, something that in the past was not done.

I hope that I have given you an idea of the interest and activities within BCA and again, thank you for your time and if you have any questions, I will be glad to try to answer them.

WASTEWATER RECYCLE FACILITY AT IBM EAST FISHKILL

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ABSTRACT

IBM East Fishkill is a semiconductor manufacturer located in New York's Hudson Valley. Continued growth on the site has increased water and wastewater demands significantly.

To meet these increased demands, a recycle facility was built to treat relatively dilute inorganic industrial wastewaters and use them as cooling tower feedwater. Because the recycle system consumes relatively "clean" waste streams, the available dilution at the final effluent discharge was reduced. This has resulted in a fluoride removal step being added to the wastewater treatment process.

The Wastewater Recycle Facility thus integrates two distinct operations. The first is a highly automated, monitored and controlled 1.2 million gallons per day process, which segregates and treats industrial wastewater for reuse. The second is a polishing process which reduces lime precipitated Fluoride and Heavy Metals Treatment Facility effluent fluoride levels via a phosphoric acid addition process. A 90-95% removal efficiency is achieved.

This integrated recycle concept has allowed the site to reuse millions of gallons of wastewater with no detrimental effects to the cooling system nor final effluent discharge quality. In fact, fluoride levels in the effluent have been lowered since the recycle system has been operational.

INTRODUCTION

IBM East Fishkill is a semiconductor manufacturing facility located in New York's Hudson Valley. Continued growth at the facility has increased our resource demands over the last two decades. This growth has created projected shortfalls in both the site's water supply and wastewater treatment capacities. To meet these shortfalls, a wastewater recycle facility was constructed.

The Wastewater Recycle Facility treats relatively dilute inorganic industrial wastewater for use as cooling tower feedwater. Several major benefits occur from the switch from potable water to recycled wastewater feedwater. Water supply requirements are reduced with the substitution of wastewater for potable water. Wastewater treatment requirements are also reduced through the evaporation of the wastewater from the cooling towers and the elimination of wastewater associated with producing potable water from well water. The net effect is less water supply required and wastewater discharged.

Several factors weighed in determining the components that make up the system. First, IBM East Fishkill is independent in its water supply and wastewater treatment. Water is supplied to the site from numerous on- and off-site production wells. Suitable new well locations were at a minimum several miles away, making future well water supply less desirable, not only from a control stand point but from a cost one as well. Treated wastewater, industrial and sanitary, is discharged into a New York State class C(T) trout stream. Final effluent discharge limits are stringent because of the stream's designation and the discharge flow in relation to the stream flow. A number of treatment facilities treat the various segregated industrial and subsequently combined industrial and sanitary wastewaters to meet those limits.

Second, the wastewater was to be used as feedwater to the site cooling loop recirculation system. The feedwater is used to replenish cooling water that has evaporated. The water is sprayed countercurrent to airflow, in the cooling tower, where evaporation cools down the remaining water. This cooled water provides the temperature differential in the condenser tube, where it is heated, then recirculated to the cooling tower. This cycle continues until the water in the loop's concentration exceeds tolerable limits. Then a portion of the cooling water is bled from the system as blowdown. An important factor is controlling the equilibrium of the system, such as, corrosion, fouling and scaling. Any increase in any of these factors could result in loss of efficiency or shutdown of the chilled water system. This is accomplished using treatment chemicals and filtration.

The last factor is a result of the first two. Because the recycle system utilizes relatively "clean" industrial waste streams, the available dilution at the effluent discharge is reduced. Meeting the stringent permit limits became a major concern.

A two year feasibility/pilot study was undertaken. The results addressed the chemical nature of the dilute inorganic industrial wastewater, its projected effects on the cooling water system, the effect of increase chemical constituent concentration on the effluent discharge limits and the system design parameters. The program was a success and a two phase facility was constructed. The major portion of the facility is utilized to recycle the wastewater. The other phase is to reduce the final effluent discharge fluoride concentration.

This paper will describe both of these systems and the results achieved by their implementation.

WASTEWATER RECYCLE FACILITY

The Wastewater Recycle Facility is an integrated system that either has constructed new facilities or has enhanced existing systems. It is, as will be shown, a complex system which depends on continuous chemical monitoring for its control. The strategy behind the facility was to be totally automated, monitor and control feedwater quality versus treat and utilize all dilute inorganic industrial wastewater, operate 24 hours per day and meet or exceed all regulatory requirements. This section describes both the wastewater recycle system and the enhanced fluoride removal system.

INORGANIC INDUSTRIAL WASTEWATER RECYCLE

The recycle facility was designed to minimize the treatment required to allow recycling of the wastewater. It has a design capacity of 1.2 million gallons per day. The facility has five main components: monitoring and control, neutralization, disinfection, filtration and storage (See figure 1.). Enhancements to cooling water system were also implemented. They were: adding side stream filtration to eliminate suspended solids and precipitated metals; changing cooling water treatment chemistry and adding automated feed systems to prevent corrosion, fouling and scaling; and adding covers on the cooling towers to prevent biological growth (these will not be discussed in any detail).

The monitoring and control system is critical to the success of the facility. Five individual wastewater streams and a mixing tank are automatically monitored on a continuous basis for six constituents (copper, chrome, ammonia, fluoride, phosphate and pH). These constituents were chosen based on their potential detrimental effects on the cooling loop system as well as their variability during the pilot study. Each had a risk of exceeding cooling tower feed water limits. Limits have been set for the individual wastewater streams as well as the mixing tank. If exceeded, that stream or the mixing tank will be diverted to the Industrial Waste Treatment Facility until it recovers.

The incoming pH is highly variable (pH from 2-13) and requires neutralization. A two step neutralization is carried out. A rough adjustment is done in the mixing tank at the Industrial Wastewater Treatment Facility and a further polishing is carried out downstream prior to filtration. Cooling water limits are pH 6.5 - 7.5.

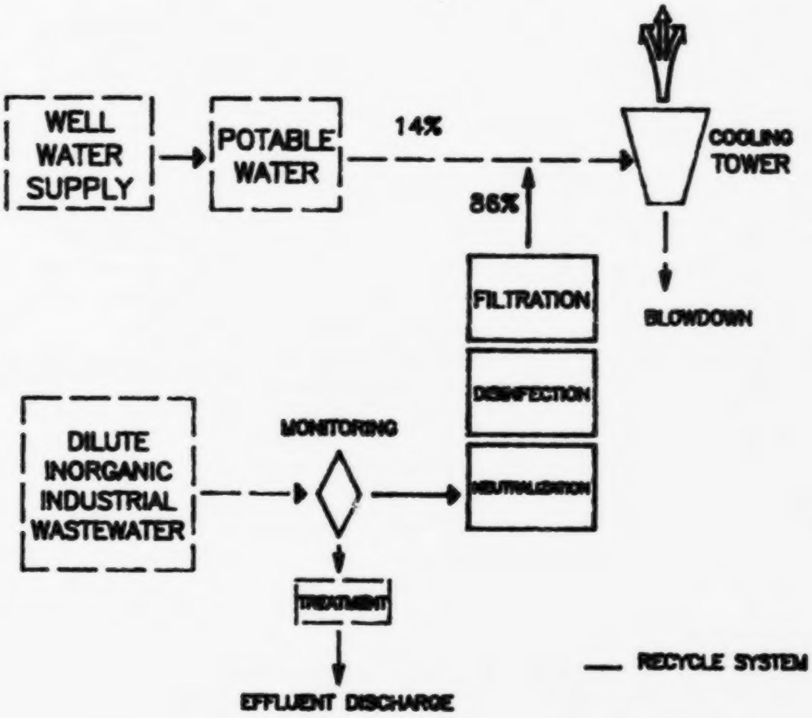

Figure 1. Wastewater Recycle System's Integration into the Cooling Tower Feedwater System.

Disinfection is accomplished utilizing sodium hypochlorite prior to the filtration step. Disinfection prior to the filters keeps them free of any biological growth. Residual chlorine level is controlled before storage to 0.7 ppm free and 1.0 ppm total chlorine. The variability of the wastewater and the conditions and length of storage make control of residual chlorine extremely difficult. This is one area in which recycled wastewater has a disadvantage over the extremely stable potable water.

The wastewater is filtered to remove any residual particles including any post precipitation occurring from neutralizing a normally acid wastewater stream. Three multimedia sand filters are utilized and feature automatic backwashing based on pressure differential. These were designed to remove ninety five percent of the incoming particles greater than 2 microns.

The recycle system depends on the quantity of wastewater produced by the manufacturing operations. This can be highly variable depending on time of day, day of week, etc. Storage of the raw (after rough neutralization) smooths out this variation and allows sizing of treatment equipment for somewhat less than peak conditions. Cooling tower feedwater demand is also highly variable, particularly time of year and time of day. An 100,000 and 200,000 gallons storage tanks handle the raw wastewater and recycle product, respectively. When the quantity of recycled wastewater cannot meet feedwater demand, potable water is added to the recycle product tank.

FLUORIDE REMOVAL PROCESS

The reduction in the available dilution at the effluent discharge was predicted to have caused the effluent fluoride concentration to be above the State Pollution Discharge Elimination System (SPDES) permit limit of 1.5 ppm average and 2.5 ppm maximum. Thus, the requirement was placed on the Wastewater Recycle Facility to reduce the fluoride concentration in the site's final effluent discharge. Several wastewater streams were evaluated for further treatment. The Fluoride/Heavy Metals Treatment Facility effluent was chosen because of its relatively low flow and high concentration compared to the other streams.

This facility treats concentrated wastewater primarily from manufacturing first rinses and has a capacity of 250 gallons per minute. Fluoride and heavy metals concentrations are reduced by utilizing a cold lime process. Lime is added to precipitate fluoride as calcium fluoride and metals as metal hydroxides. A flocculant is added, and the wastewater is clarified. The sludge is dewatered and sent to a cement kiln as a raw material. The clarifier overflow (Fluoride/Heavy Metals Treatment Facility effluent) fluoride concentration is further reduced in the Recycle Facility's fluoride removal process.

Tricalcium phosphate had been successfully utilized to remove fluoride spikes in the site's Industrial Wastewater Treatment Facility. The fluoride reduction process is based upon the chemistry of the tricalcium phosphate - fluoride interaction. Research was done in the potable water treatment field to produce tricalcium phosphate by adding phosphoric acid to a lime slurry. (1,2) The clarifier overflow characteristics, high pH (11-12) and calcium concentration (1400 ppm), allowed this concept to be utilized. The Fluoride/Heavy Metals Treatment Facility's reduction process (clarifier overflow) is now followed by the addition of phosphoric acid. The wastewater is agitated and an insoluble fluoroapatite is formed which is then settled in a clarifier. The resultant sludge is mixed with the lime sludge and dewatered. Figure 2 illustrates the fluoride removal process.

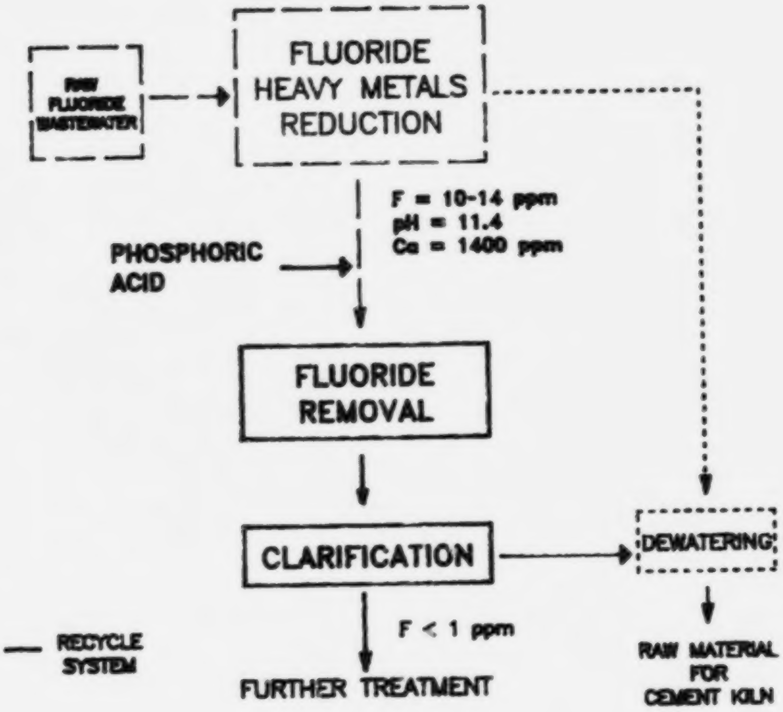

Figure 2. Fluoride Removal Process Utilizing Phosphoric Acid.

RESULTS

Both the wastewater recycle and the fluoride removal systems have exceeded their goals. Expansion of well water supply and wastewater treatment systems have been minimized. Capital expenditures based on implementing the Wastewater Recycle Facility have been cut by fifty percent and operating costs lowered. The final effluent is well within the permit limits and fluoride concentration has in fact been lowered.

WASTEWATER RECYCLE FACILITY

The facility has fed the cooling towers for several years. Water savings for 1989 have reached approximately 200 million gallons (over 500,000 gallons per day average). This is 86% of the total cooling tower feed water. The savings remain seasonal (see figure 3), only limited by the dilute inorganic industrial wastewater's quantity and quality.

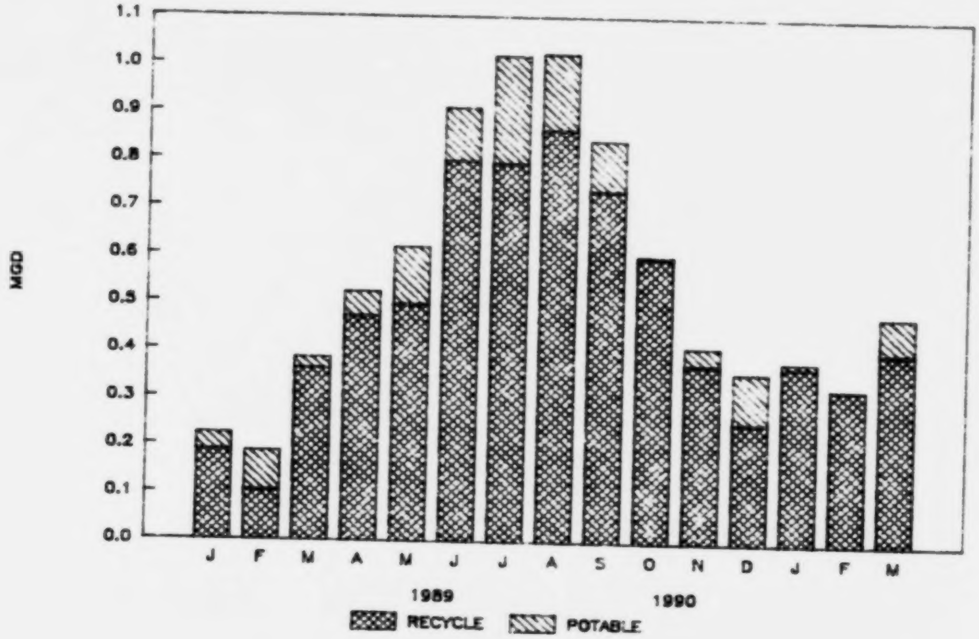

Figure 3. Cooling Tower Feedwater Sources

The recycled wastewater is superior to potable water in that its total dissolved solids (a measure of recirculation cycles) is less than potable water. Cooling loop cycles of concentration are averaging from 5-7, the same as with potable water. Variability in recycled wastewater characteristics does require more frequent adjustment of cooling loop treatment chemistries than does potable water. No detrimental effects, however, such as corrosion, scaling or fouling have been caused by utilizing the recycled wastewater.

FLUORIDE REMOVAL PROCESS

The goal of this process was to reduce the fluoride concentration in the Fluoride/Heavy Metals Treatment Facility effluent so that the SPDES permit limit of 1.5 ppm would be met. This goal was exceeded in that the effluent discharge concentration has been reduced 50% since 1986 (before the Recycle Facility). For comparison another effluent constituent, copper, shows stability over the period (see figure 4) although no steps were taken to reduce its concentration.

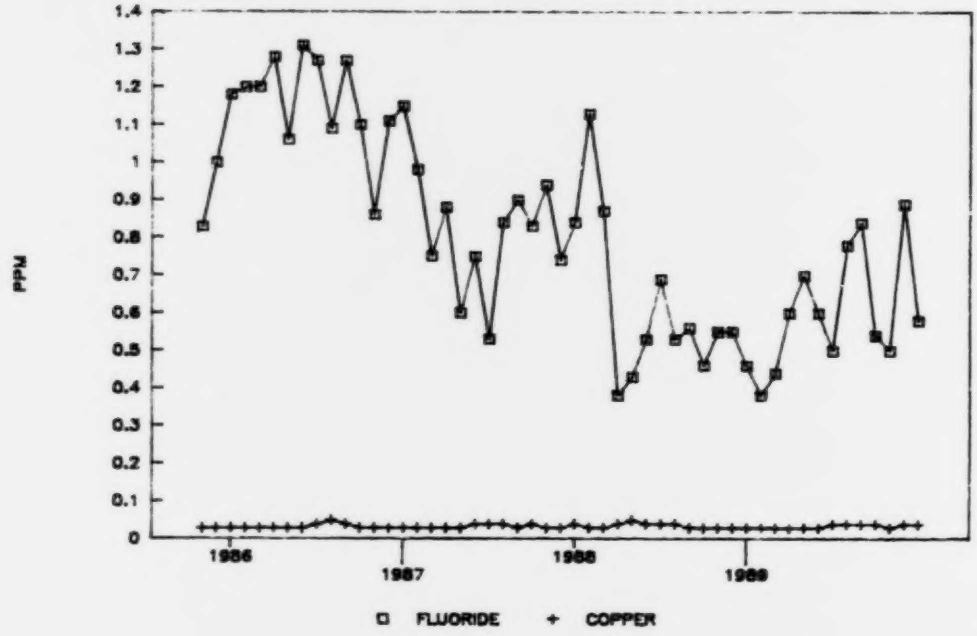

Figure 4. Final Effluent Discharge
Fluoride\Copper Concentration.

The effluent from the fluoride removal process has averaged 1 ppm. This is over a 90% reduction. Fluoride concentration is controlled by adjusting the phosphoric acid dosage. Phosphate concentration in the process effluent could be detrimental to subsequent treatment facilities. The sanitary facility could be especially effected because it is a biological treatment facility. Phosphate levels have been controlled by controlling the dosage rate of phosphoric acid. Correlation between acid dosage and effluent concentration is excellent - 0.9.

SUMMARY

The Wastewater Recycle System has met all its objectives. The system has reduced well water supply consumption by approximately 500,000 gallons per day in 1989. On a peak day its saved well over a million gallons. Fluorides in the final effluent discharge to a class C(T) trout stream have not only met the limit, but have been reduced by 50%. This is from an average of 1.15 ppm in 1986 to 0.57 ppm in 1989.

Both well water supply and wastewater treatment system expansions have been minimized by reducing the quantity of flow required. Expansions of approximately one million gallons per day would have been required to keep up with peak monthly flows. A precious natural community resource, water, was saved.

Capital and operating costs were avoided by utilizing the Wastewater Recycle Facility. Capital cost avoidance amounted to 50%. Therefore, recycling makes good business sense.

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State Mandated Pollution Prevention - Legislative and Regulatory Initiatives to Compel Reduction of Use of Hazardous Chemicals

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I. INTRODUCTION.

There has been a growing trend at the State level toward the enactment and consideration of legislative bills and regulatory programs to require companies to reduce their use of hazardous chemicals in manufacturing processes. This paper explains current legislative and regulatory initiatives in several states and distills the state approaches with the objective of suggesting a uniform model state approach towards pollution prevention. A uniform state approach is urgently needed, particularly for companies with multi-state facilities. Without a uniform approach, states will create disincentives and obstacles to the development of pollution prevention.

II. CURRENT STATE REGULATORY AND LEGISLATIVE INITIATIVES.

1. California.

In 1989, California enacted the Hazardous Waste Reduction and Management Review Act. The Act requires industries which generate 12,000 kilograms or more of hazardous wastes annually to review their operations for potential measures for reducing waste generation and to prepare plans showing an implementation schedule for selected source reduction measures. The Act also requires these generators to submit a performance report which presents the results of their waste reduction planning efforts.

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The Act is administered under the California Waste Reduction Program with other waste reduction programs. These programs cover several areas, all directed to prevent land disposal of hazardous waste and, ultimately, its generation. The Hazardous Waste Reduction Grant Program provides funding to universities, governmental agencies and private organizations for the research and development of hazardous waste reduction, recycling and treatment technologies. The Waste Audits Program encompasses facility site visits to identify hazardous waste generated and current waste management practices. The Waste Exchange Program publishes a directory of industrial recycling operations and assists hazardous waste generators in locating operations which can use their waste streams for feed stocks. The Technology Transfer Program, finally, develops and disseminates information on waste reduction, recycling and treatment technologies and develops strategies to encourage industry to eliminate or reduce the volume and toxicity of hazardous waste.[2]

2. Florida.

The Florida Department of Environmental Regulation (FDER) has received one of fourteen Integrated Training and Technical Assistance (RITTA) grants to develop a State Training Action Plan (STAP) for Florida state personnel and hazardous waste generators. The STAP Program is directed toward the objective of reducing solid waste, including hazardous waste, by 30% by 1994 and significantly reducing the number of small quantity hazardous waste generators not in compliance with hazardous waste management rules. The Program has identified deficiencies in Florida's system for developing and delivering compliance oriented RCRA training and technical assistance. The STAP Program has recommended that Florida's solid and hazardous waste training and technical assistance programs be organized and administered as a formal consortium of State universities and community colleges to provide training and technical assistance through six regional training centers, called the Florida

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[2] Information provide by Alternative Technology Division, Toxic Substances Control Program, State of California, Health and Welfare Agency, Department of Health Services, 714-744 P Street, P. O. Box 942732, Sacramento, California 94234-7320; Telephone No. (916)322-3670.

Environmental Training and Technical Assistance Network (FETTA-NET).

FDER has primary responsibility for providing technical assistance through its waste management program offices and the Waste Reduction Assistance Program (WRAP).[3]

3. Illinois.

The 1989 Illinois Toxic Pollution Prevention Act, SB 1044, established the Toxic Pollution Prevention Program within the Illinois Environmental Protection Agency ("Agency"). The Program consisted of identifying federal and state laws relating to waste disposal and toxic substances release, promoting increased coordination of efforts to administer and enforce those laws, and determining how Agency programs should be coordinated or modified to promote toxic pollution prevention. The Program is required under the Act to develop a toxic pollution prevention manual for Agency inspectors and permit reviewers, establish procedures for expediting permit application reviews, and to develop a list of toxic substances for priority toxic pollution prevention consideration, based upon examination of toxic release inventory reports filed under the Federal Emergency Planning and Community Right to Know Act of 1986.

The Act also established a Toxic Pollution Prevention Assistance Program at the Hazardous Waste Research and Information Center. The Program established at the Hazardous Waste Research and Information Center (HWRIC) under the Act increases the Center's waste reduction work. The Center exists within the Illinois Department of Energy and Natural Resources (ENR) and promotes waste reduction through a series of programs. The Industrial and Technical Assistance (ITA) Program provides direct technical assistance to state industries, communities and citizens with hazardous waste management problems and administers the annual Governor's Pollution Prevention Awards to recognizing efforts to reduce hazardous and non-hazardous waste. The Center has established cooperative college and university programs designed to augment the implementation of the Program, and can, if it chooses, set financial charges for participation in the Program with the resulting monies to be deposited in a Toxic Pollution Prevention Fund.

Beginning January 1, 1990, any person may submit to the

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[3] June 5, 1990 Final Draft Report, "A State Training Action Plan For Waste Management", prepared by the Waste Management Training and Technical Assistance Council, in conjunction with the University of Florida Center for Training, Research and Education for Environmental Occupations, 3900 Southwest 63rd Boulevard, Gainesville, Florida 32608-3848, Contract No. HW113.

Agency toxic pollution prevention plans involving innovative production processes or new applications of technology. The Agency must approve proposed plans if feasible under applicable law and consistent with prudent environmental practices. Agency approval may include expedited coordination and processing of applicable permit applications, cooperation with requests for applicable variances, adjusted standard or site specific standards and appropriate technical assistance.

Illinois, working with other States and USEPA, has developed the Waste Reduction Advisory System (WRAS) which provides waste generators with options for reducing and recycling industrial waste. WRAS has two components: a Waste Reduction Audit Checklist (WRAC) and the Waste Reduction Information Bibliography (WRIB). Illinois has received one of the RCRA Integrated Training and Technical Assistance (RITTA) Grants from USEPA. The Agency and HWRIC are working together to develop and implement a five year State Training Action Plan (STAP), to expand the RCRA Hazardous Waste Training Program for Agency personnel, for others providing technical assistance, and for generators, and to develop and implement pilot technical assistance projects focusing on waste reduction.

Illinois is also one of six states selected by USEPA to implement a national research demonstration program called the Waste Reduction Innovative Technology Evaluation (WRITE) Program. The WRITE Program is designed to evaluate the use of innovative engineering and scientific technologies to reduce the volume and/or toxicity of waste produced from the manufacture, processing and use of materials.[4]

4. Louisiana.

In 1987, Louisiana enacted the Louisiana Waste Reduction Law, Act No. 657, requiring every Louisiana generator of waste to provide a report to the Louisiana Department of Environmental Quality regarding that generator's waste reduction efforts. Generators must use data in their reports sufficient to convey an accurate analysis of waste reduction previously accomplished or to be accomplished in the future. The data must be given on an output production basis and give a final waste reduction percentage based upon waste generation and production data, not based solely upon changes in the absolute amounts of waste generated.

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[4] Illinois Hazardous Waste Research and Information Center Annual Report, July 1, 1988 - June 30, 1989, submitted to the ENR Board of Natural Resources and Conservation, February 1990, HWRIC AD 89-014.

Louisiana in 1984 enacted Act No. 803 which required a research and development fee to be charged for all permits, licenses, registrations or variances under the environmental laws. The fees, set by formula, are designed to encourage alternative and environmentally sound methods of destroying, recycling and neutralizing hazardous waste. The fees generated fund the Louisiana Alternative Technologies Research and Development Trust Fund.[5]

5. Minnesota.

In 1990, Minnesota passed the Minnesota Toxic Pollution Prevention Act[6]. The Act establishes toxic pollution prevention as state policy through several mechanisms. The Act expands the responsibilities and staff of the existing Minnesota Technical Assistance Program (MnTAP) which assists companies in identifying and implementing pollution prevention measures. In addition, the Act provides $150,000 in grants for projects to assess the feasibility of pollution prevention technologies and establishes a Governor's Annual Program for excellence in pollution prevention. Each facility which reports toxic chemical releases under the Community Right to Know Act must develop a toxic pollution prevention plan establishing goals for reducing or eliminating toxic pollutant releases. The plans are confidential but each facility must submit an annual progress report based upon the plan to the Minnesota Pollution Control Agency (MPCA). The progress report is available for public review. If the MPCA determines that a report does not contain the required information, the company may be subject to enforcement action, following a public meeting in the community where the facility is located. Citizens are permitted to petition the MPCA to review deficiencies in a report.

The Minnesota Office of Waste Management (OWM) must submit annual progress reports to the state legislature commencing January 1, 1991, assessing the regulatory, economic, educational and institutional barriers to pollution prevention. The OWM must also prepare a report to the legislature by January 1, 1993 evaluating whether to require companies to report on their use of toxic chemicals.

Facilities required by the Community Right to Know Act to report toxic chemical releases must pay an annual fee of $150 for each toxic pollutant released. In addition, each facility that releases more than 25,000 pounds of toxic pollutants annually must pay $.02 per pound not to exceed $30,000, and a facility that releases less than 25,000 pounds per year must pay a $500 fee. Large quality generators of hazardous waste not required to report releases under the Community Right to Know Act must pay a fee of $500. The first fees are due on January 1, 1991 and are expected to raise approximately $1.2 million.

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[5] Act No. 803 (1984), §§1065, 1065.2.

[6] Chapter 115D, Minnesota Statutes.

6. New Jersey.

The New Jersey legislature is now considering the Pollution Prevention Act, Senate No. 2220. The Act establishes an Office of Pollution Prevention in the New Jersey Department of Environmental Protection and a State-wide goal of a 50% reduction in the use or discharge of hazardous substances over five years. The Act also establishes a Pollution Prevention Advisory Council in the Department responsible for reviewing implementation of the Act and the Department's criteria for pollution prevention plans. Every owner and operator of an industrial facility must prepare a hazardous substance inventory and certain facilities must submit pollution prevention plans to the Department. The Act applies to industrial facilities in the manufacturing sector employing more than 10 full-time employees, and at which 25,000 pounds or more of a hazardous substance are manufactured, or at which 10,000 pounds or more of a hazardous substance are used. The substances required to be inventoried, and the use of which is required to be reduced, are the hazardous substances regulated under the New Jersey Worker and Community Right to Know Act. Of the facilities submitting inventories, the Department would select between 10 and 15 facilities during the first year to submit pollution prevention plans, with each year the number of facilities required to submit such plans increased by 50%.

7. Ohio.

In 1979, Ohio established the Ohio Technology Transfer Organization (OTTO) to address energy conservation and to serve as an industrial extension service for business and industry. OTTO agents provide free technical assistance to Ohio business and industry and are located at 32 state supported two year technical and community colleges and universities. In 1986, Governor Celeste named OTTO to spearhead Ohio waste minimization activities and also created a Waste Minimization Task Force (WMTF) including representatives from industry, environmental groups, state personnel and academia.

Battelle Memorial Institute, under contract with the Ohio Department of Development, has prepared a report on hazardous waste minimization identifying lack of information and lack of technical assistance from the regulatory and non-regulatory community as the principal reasons for lack of progress in waste minimization in industry. The Fisher/Troy Toxic Use Bill, introduced in the Ohio legislature, would assess a $.10 per pound fee for hazardous waste disposal with the revenue to go (i) to a hazardous waste technical assistance center, (ii) to increased technical assistance, and (iii) to increased regulatory control.

Ohio has also received one of the RCRA Integrated Training and Technical Assistance (RITTA) grants from USEPA[7].

8. Oregon.

In 1989 Oregon passed the Toxic Use Reduction and Hazardous Waste Reduction Act which required covered Oregon businesses to submit toxic waste reduction and hazardous waste pollution plans.[8] The plans must contain written policy statements articulating upper management and corporate support for the planning process, a written statement of plan goals, scope and objectives, numeric reduction goals for certain toxic substances and hazardous waste streams and analysis of toxics use and hazardous waste streams. The development of cost identifying accounting systems, the identification of waste reduction opportunities and implementation strategies, establishment of employee awareness and training programs and the implementation of technically and economically practical toxics use reduction and hazardous waste reduction options are also required. Annual progress reports in implementing the plans must be submitted to the Oregon Department of Environmental Quality (DEQ).

Businesses covered by the Act include: large users, those users of toxic chemicals required to report under the Federal Community Right to Know Program; fully regulated hazardous waste generators, those generators generating more than 2200 pounds per month of hazardous waste, or more than 2.2 pounds per month of acutely hazardous waste; and small quantity hazardous waste generators, those generators which generate between 220-2,200 pounds per month of hazardous waste. Conditionally exempt generators of hazardous waste are not required to develop plans, although they are eligible for technical assistance under the program. Large users and fully regulated generators must file their plans with the DEQ by September 1, 1991. For small quality generators, initial plans are due by September 1, 1992. Progress reports must be submitted to the Oregon DEQ each year thereafter.

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[7] June 5, 1990 Memorandum on Waste Minimization in Ohio, Prepared by Dawn Palmieri, Ohio Technology Transfer Organization (OTTO).

[8] House Bill No. 3515.

The Oregon approach thus covers three areas: (1) providing technical assistance to affected industries; (2) monitoring the use of toxic substances and generation of hazardous waste; and (3) requiring affected industries to engage in comprehensive planning and to develop measurable performance goals.

9. Tennessee.

In March 1990, Tennessee passed the Tennessee Hazardous Waste Reduction Act of 1990.[9] The Act requires hazardous waste generators to submit hazardous waste reduction plans to the Tennessee Department of Health and Environmental (DHE). The plans must describe how the generators will reduce their hazardous waste generation by 25% by June 30, 1995. Large quantity generators, defined as generators generating 2.2 pounds of acutely hazardous waste or 2,200 pounds or more of hazardous waste in any month, have until January 1, 1992 to submit their plans. Small quantity generators, defined as generators generating not more than 220 and 2,200 pounds of hazardous waste in any month, must submit their plans by January 1, 1994.

The hazardous waste reduction plans must contain a dated and signed policy articulating management support for waste reduction, and a specification of scope and objectives, including evaluation of technologies, procedures and personnel training programs. Specific goals must be set for hazardous waste reduction with a description of technically and economically practical hazardous waste reduction options and a schedule for implementation, a description of hazardous waste accounting systems with specific source reduction goals, a description of employee awareness and training programs, and a description of how the plan has been or will be incorporated into management practices and procedures. All generators must annually review their waste reduction plans and submit hazardous waste reduction progress reports to DHE. Generators failing to file the required reports are subject to civil penalties of up to $10,000 per day.

III. DISTILLING THE VARYING STATE APPROACHES - DEVELOPMENT OF A UNIFORM MODEL COST EFFICIENT APPROACH TO STATE POLLUTION PREVENTION.

The varying state approaches illustrated by these state waste minimization programs present significant problems for industry, particularly manufacturing companies with multi-state facilities. Complying with different state waste minimization requirements can prevent companies from adopting a cost-efficient and uniform approach to reduction of their industrial process waste streams, particularly where reductions are dependent upon capital equipment expenditures and long-range engineering and planning requirements. The development of a uniform model cost-efficient approach to pollution prevention on the state level is urgently needed. If a model uniform approach is not adopted, the ensuing confusion and divergence in pollution prevention approaches could significantly hinder waste minimization progress.

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[9] Tennessee Hazardous Waste Reduction Act of 1990, House Bill No. 2217.

Certain fundamental elements from different State approaches can be distilled to create a uniform model approach. First, the identification of goals or targets for hazardous waste generation for all industries should be pursued but such goals should be simply that--goals rather than statutorily or regulatory mandated targets. Common goals of 25% reduction of hazardous waste generation by the year 1995 and 50% reduction by the year 2,000 have been identified in some states and can serve as useful guideposts for industry. Programs for hazardous waste minimization should require reduction from a facility specific baseline. Baselines should be identified through use of existing environmental reporting mechanisms. The federal Right to Know legislation now requires companies to report annual manufacturing and use of toxic chemicals on an annual basis. Those reported inventories should serve as the basis for required waste reduction plans to be submitted every three years to state environmental protection agencies with annual required progress reports. The agencies should be directed to review the submitted plans against the general goals of 25% reduction by the year 1995 and 50% reduction by the year 2,000, but the reductions should not be mandatory for each facility. Instead, the state agencies should be empowered to require each facility which submits a plan to document its progress against the target goals based upon best available waste reduction technology available for manufacturing progress within its industry. Deviations from the 25% and 50% goals of reduction therefore, are permitted based upon the available technology and the circumstances within the industry, permitting market and economic consideration to be factored in.

The model uniform approach requires each state to establish grant programs to fund waste reduction programs and to provide special technical assistance in waste minimization, including training using the resources of colleges, universities and engineering schools. Each state would also be required to establish information clearing houses to facilitate the transfer of technology for hazardous waste reduction.

Fees for hazardous waste disposal on a per pound basis should be established to fund the state technical assistance and information clearing house programs, and to provide a further financial incentive for hazardous waste reduction.

The model uniform state approach suggested here is but one of several possible scenarios, but the fundamental point is clear - a uniform state model approach is critically needed. Serious consideration should be given to establishing a national state hazardous waste minimization congress, with representatives of the environmental protection agencies of the fifty states invited to prepare a model uniform state waste minimization bill.

THE LINEAR TUBULAR REACTOR

A NEW PROCESS FOR RECLAIMING USED OILS AND DECONTAMINATING OTHER HAZARDOUS WASTES VIA MOLECULAR THRESHOLD DISTILLATION AND MOLECULAR CONDENSATION

by

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Summary

A patented linear tubular process is applied to reclaim liquid waste materials, especially used oil, by means of a total vacuum distillation within the critical energy level of the molecular stability followed by subsequent fractionated condensation. The simple assembly of the reactor enables trouble free operation with locally trained personnel.

The automatic control of the operation is tuned so precisely that the retention time of molecules at the desired energy level can be adjusted to within milliseconds. Also, thermal energy adjustment is possible to within 0.2 degrees C, even for large flow rates. The use of non-conventional energies is under trial at present, showing even better control possibilities.

A pilot plant has been operating since September, 1988, with a throughput of 400 kg/hr. It is constructed of standard machine parts made from plain carbon steel. This plant was sponsored by the German government.

For used oils, the yield is around 95% depending on the volume of contamination. By means of the linear tubular process, hazardous compounds of the used oils are largely removed: chlorine, sulphur, lead, polychlorinated biphenils (PCB's), and polychlorinated hydrocarbons (PAH's). All residual contamination can be removed with a modest treatment of 0.4% sodium, or stoichiometric amounts of hydrogen.

The residue sludge contains only environmentally irrelevant compounds because heavy metals and the original additives are chemically bound. The sludge can be used as fuel in smelters or in the cement industry. A conversion into recycled products is also possible by adding other residual materials, e.g. ash from combustion processes, lime products, salts from gas flue cleaning devices, or bituminous road binders.

The exhaust gases of the vacuum pumps are recycled into the process in such a way that there is no detectable odor around the reactor. They are fed into the combustion air of the burners after scrubbing by absorption to waste oil. Noxious substances of the flue gases (CO, $SO2$, NO_x, dust ingredients) from the burners are 20% below the limits of the German Regulatory Rules.

A tubular reactor with a capacity of 50,000 tons annual throughput can be installed for about $ 8.8 million. The operating costs are $ 38.20 per ton of waste oil, compared to $ 97.00 for the customary sulphuric acid/Fullers earth process. These savings in operating costs alone will pay for the capital costs of the reactor within two years.

The success of this project prompted the German government to sponsor additional research valued at $ 11.7 million.

Background

The reclamation of used lube oils is gaining importance for environmental protection and preservation of non-renewable resources.

The annual amount of waste oil in the Federal Republic of Germany has reached 500,000 tons, of which 330,000 tons were reclaimed in 1985. The established sulphuric acid/Fullers earth refining process results in 22 kg of additional hazardous waste per 100 kg of used oil. The resulting acid tar and oil-charged Fullers earth represent complex and costly disposal problems.

In addition to the high costs of the sulphuric acid/Fullers earth process itself and the disposal costs of the resulting special waste, further problems arise: risks for the environment during the transport and utilization of these special wastes, expensive waste water treatment, necessity for stainless steel, etc.

The linear tubular reactor developed by ENTRA has the advantage that it does not create any additional wastes. It simply separates the oil from the contaminating materials. The output is clean oil, and waste in the form of sludge. There is no more sludge than was already present in the input oil.

In other words, the recovery process causes a complete separation of the waste oil into valuable compounds as distillate, and trashy products as residue, without the addition of major amounts of auxiliary materials. During the distillation process, some chemical agents can be added to accomplish a total elimination of residues of chlorine, sulphur, nitrogen, polycyclic aromatics, or PCB's.

Attracted by the advantages of this novel application of physical separation, the Ministry of Research and Technology of the German Federal Government supplied grants for the operation of a pilot plant at ENTRA within the program "Environmental Research and Development."

ENTRA has received two patents on its work, namely, DE 3638606 and DE 3640978, together with the corresponding foreign patents. Further patent applications are pending.

Description of Process and Equipment

Based on years of research and experience in the field of high temperature processing of organic substances, ENTRA engineers thought that oil molecules could be made to drop hetero atoms before being destroyed (cracked) by thermal energy. Experiments applying thermal and non-conventional energies confirmed the hypothesis.

By means of precisely controlled levels of energy and retention time for each molecule, specific conditions can be maintained which lead to dropping the hetero atoms but not to cracking of the carbon chain. A newly developed control technique allows keeping the retention time within milliseconds, and maintaining the temperature within 0.2 degrees C of the desired level.

The tubular reactor used for this process consists of a single tube in which a liquid product stream is continuously transferred into steam by means of increasing temperature, followed by fractionated condensation. The evaporation process or the chemical reactions take place during the controlled flow through exactly tempered zones of the tubular reactor at relatively high velocities.

The small flux of materials enables rapid changes of pressure and temperature, and thus instantaneous adaptation to the different bonding energies of the substances to be treated. Desired chemical reaction can be achieved at points of the tubular reactor with the corresponding level of activating energy by the dosage of auxiliary process aids.

With the help of a specially developed measuring and control technique, a process sensitivity can be reached which is unmatched by other installations, such as autoclaves, fractionating columns, or other reclaiming units.

During continuous operation, yields of up to 97% can be reached, depending on the quality of the used oil and the efforts for after-treatment. All impurities remain almost quantitatively in the residue which can be produced either tarry or as granulate. A coking oven designed by ENTRA can be used to convert the granulate into petrol coke. It contains all solid waste, such as soot, heavy metals, and other impurities. Sulphur and chlorine become available as inorganic salts. A complete dechlorination of used oil, including the removal of all PCB's, can be achieved with metallic sodium. During this process, all chlorine compounds are converted into sodium chloride.

Results

Table 1 contains the costs for a plant with a capacity of 60,000 tons per annum using the ENTRA process, as well as comparative costs of the well-known sulphuric acid/Fullers earth process.

At ENTRA, the prototype plant has been in operation since 1988 with varying parameters. The following results have been obtained:

Treating used oils with chlorine contents between 0.8% and 2.0%, and sulphur contents of about 0.8%, a reduction of the chlorine and sulphur levels by 30% to 70% could be achieved without the addition of auxiliary chemical agents. The yield exceeded 95%. The residues amounted to less than 5%. Chlorine and sulphur compounds react with the metals from the additives for wear to form salts which are concentrated in the residues.

All valuable long-chained hydrocarbons come as a result of the distillation as distillates after a fractionated condensation. Aging or cracking of the distillates could not be detected.

The fractions required only a modest after-treatment for brightening purposes with 0.4% sulphuric acid and 0.7% Fullers earth, or with 0.4% sodium, or with stoichiometric amounts of hydrogen. In the later case, hazardous substances, such as chlorine, sulphur, and PCB's are removed below detection levels. The percentage of PAH's declines to 30 - 40% of the original value.

The resulting residue only contains environmentally irrelevant compounds. It could be used as fuel for industrial purposes without any problems. A conversion into easily disposable or recyclable products is possible by adding other residual materials, e.g., ashes, lime products, salts from gas flue cleaning devices, bituminous road binders.

Thermal treatment of the residue at 500 to 600 degrees C leads to a solid bottom of coke, and salt compounds from chlorine and sulphur. The simultaneously developing gases could be scrubbed by absorption to waste oil in a gas-washer and thus fed back into the process.

The exhaust gases from the vacuum generators with possibly hazardous substances (e.g., mercaptanes) are disposed of by feeding back into the combustion air for the burners after scrubbing by waste oil. Using this method, no molestation by odor was observed.

Harmful substances of the flue gases from the burners are negligible. Noxious compounds of the flue gases (CO, SO2, NOx, dust ingredients) are 20% below the limits of the regulations of the German authorities.

The quality of the resulting product is completely in line with the requirements of the market. In Table 2, comparative data is given using the specifications of a major lube oil manufacturer for a solvent neutral ISO VG 32 versus independent test results for ENTRA oil. It can be seen that all values meet the requirements.

TABLE 1

Comparison of the Sulphuric Acid/Bleaching Earth (S/B) Process with the ENTRA Linear Tubular Process
(does not include Gate Delivery Costs for Used Oil)

Process	INPUT				OUTPUT					
	Waste Oil	Auxiliary Agents	Process Costs	Total Input	Base Stock	Solvents	Losses	Waste Residuals	Total Output	Balance
S/B t	60,000	6,168		66,168	48,787	3,925	1,120	12,336	66,168	
Other Parts	107	11[2]		118	87	7	2	22[3]	118	
Value $/t		(48.50)	(97.00)		176.50	58.50		(88.25)[4]		
Profit/Loss (Million $)		(0.3)	(5.8)	(6.1)	8.6	0.2	(0.1)	1.0	7.8	1.7
ENTRA t	60,000	240[5]		60,240	52,685	3,925	600		60,240	
Other Parts	107	0.4		107.4	94	7	1		107.4	
Value $/t		(2,353.00)	(38.20)		176.50	58.80				
Profit/Loss (Million $)		(0.6)	(2.3)	(2.9)	9.3	0.2			9.5	6.6

Notes:
1. Containing 5% contamination
2. 6.6 parts Sulphuric Acid plus 4.4 parts Bleaching Earth - $48.50/ton
3. 15 parts Acid Tar plus 7 parts Oil Soaked Earth
4. Disposal Costs $88.25/ton
5. Sodium, calculated at $2,353/ton
6. ( ) indicates profits or losses in Million $

TABLE 2

Typical Values of a Reclaimed Base Stock According to the ENTRA-Process
Compared with the Specifications of a Major
Lube Oil Producer for a Solvent Neutral

ISO VG 32

	Method	Dimension	ENTRA Reclaimed Basestock	Standard Specifications Solvent/Neutral
Appearance			bright, clear	bright, clear
Density	DIN 51757	kg/m3	870	865 - 875
Color	ISO 2049		1.5	max. 1.5
Flashpoint o.c.	ISO 2592	degree C	220	min. 210
Viscosity at 40 C	DIN 51562	mm2/s	31.0	29.0 - 32.5
Viscosity at 100 C	DIN 51562	mm2/s	5.2	5.0 - 5.4
Viscosity Index	ISO 2909		97	min. 95
Pour Point	ISO 3016	degree C	-14	max. -9
Conradson Residue	DIN 51551	wt %	0.01	max 0.02
Ash Content	EN 7	wt %	<0.001	max. 0.01
Neutralization No.	DIN 51558	mg KOH/g	0.03	max. 0.05
Aromatic Content	DIN 51378	wt %	ca. 7.0	max. 8.0
Sulphur Content	DIN 51400	wt %	<0.04	max. 0.8
Chlorine Content	DIN 51557	mg/kg	<5.0	max. 20
Calcium Content	DIN 51391	mg/kg	35	max. 50
Zinc Content	DIN 51391	mg/kg	<20	max. 50
Water Content	DIN 51777	mg/kg	<2.0	max. 50
Demulsifying Property	ASTM D1401	ml	30-30-0	40-40-0
Evaporation Loss	DIN 51581	wt %	12	max. 15

Operating Cost Estimates

Based on the experience gained so far with the pilot plant, the design of the plant results in a high degree of reliability due to simple construction and the use of standard components. These features lead to easy maintenance, and extended meantime between failure.

Cost estimates for a plant having a capacity of 50,000 tons annually are as follows:

Total capital investment	: $ 8.8 million
Heating oil consumption	: 230 to 250 kg/hr (light oil can be used)
Electric power consumption	: 180 to 220 kw/hr
Revolving water circulation	: 30 to 40 cubic meters/hr, with an inlet temperature of 25 to 30 degrees C.
Exhaust gases	: Only flue gases from the oil burners, within the limits of German regulations.
Residue	: To be used as primary fuel after congealing, or reprocessing for metal or cement industry.
Staffing	: 1 foreman and 2 craftsmen (locksmith, electrician) on an on-call basis as the unit works fully automatically and stops in case of failure.
Materials	: Constructed of low carbon structural steel (easily available in all countries).
Total operating costs	: $ 38 per ton of input waste oil.
Recovery	: Depending on condition of input oil, around 95% oil and 5% sludge.

Previous Production Units Designed by ENTRA

For the construction of the linear tubular reactor for reclaiming waste oil, ENTRA relied on its experience gained from constructing other commercial production units designed for carbon compounds:

1976 Development and construction of a pollution free plant to integrate electrode carbon on a commercial scale for Vereinigte Aluminium Werke. During the process, bitumen, pitch, and oils are heated far above the cracking limits without decomposition.

1984 The first linear tubular reactor for commercial scale coal liquefication was installed for Salzgitter AG. Applying a novel energy and controlling concept, temperatures up to 530 degrees C are applied at a pressure of 1,500 bar. This plant was sponsored by the German government with DM 320 million.

1985 ENTRA succeeded in binding solid particles in the micrometer range, as well as liquid and gaseous organic compounds, e.g., pitch vapors, to water without any chemical or auxiliary substances. An exhaust gas cleaning unit using this process was developed and supplied to Sigri AG.

1986 Important parameters of molecular bonding forces of petrochemical products and their influence on other chemical compounds (e.g., used oil and additives) could be calculated.

1988 A pilot plant for reclaiming used oil with a capacity of 400 kg/hr went into operation in cooperation with Suedoel AG. This company has refined waste oil for about 90 years, and gained comprehensive experience in this field. The pilot plant was supported by the German government with DM 2.5 million.

Other research and development problems solved by ENTRA include the construction of fans for continuous operation at 1,400 degrees C, and mixer and kneading machines for 700 degrees C at 50,000 Nm torque.

Based on the experience gained with new designs over many years, expertise is at hand for the safe layout of a linear tubular reactor for reclaiming used oil.

Purposely designed for simple operation and maintenance, locally trained operators and maintenance personnel can be used. Low operating and maintenance costs are expected.

Following the successful operation of the pilot plant, a production unit having a capacity of 50,000 tons per annum is now under construction. Quotations for other capacities are available.

Future Research at ENTRA

The following research and development is planned:

Omission of the after-treatment with sulphuric acid and activated clay by adding sodium or other harmless products, such as, red mud from the aluminum industry. Trials indicate that water white and clear fractions can be obtained without further after-treatment.

Further reduction or complete removal of PAH's by more precise tuning of the conditions of reaction, or the application of auxiliary agents, e.g., hydrogen.

Further reduction of the chlorine and sulphur contents via catalytic reactions with safe rest products not controlled by waste legislation.

Enlarging the spectrum of input materials to chlorinated hydrocarbon solvents and other substances like PCB, polychlorinated dioxines and furanes with the goal of an economic and environmentally safe disposal possibility.

Since 100% of the PCB's in the waste oil is removed with the addition of small amounts of sodium, the German government is now sponsoring additional research work to remove PCB's from other wastes by the ENTRA method.

APPROACHES TO REDUCING ENVIRONMENTAL RISK THROUGH POLLUTION PREVENTION

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Introduction

Much of what has occurred in our recent environmental history has led to the concept of "pollution prevention". In fact, the U.S. Environmental Protection Agency (EPA) Administrator, William Reilly, has summed up Pollution Prevention as the environmental goal for the 1990's (Reilly, 1990). However, as we presently look at pollution prevention or waste minimization there is another basic fundamental question that needs to be answered. How does pollution prevention reduce environmental risk?

It would seem to many of us that a reduction in waste would have a direct correlation with a reduction in environmental and human health risks. However, the pollution prevention approach does not bring into the picture the concept of risk assessment and risk management as part of the overall decision-making process. Industrial efforts have focused largely on the end-of-pipe technologies to minimize waste that may not necessarily reduce risk but only transfer pollutant problems from one media to another. This is not to say that risk assessment be the driving force behind waste minimization decisions, but rather be utilized as a tool along with economic and technical consideration to give the decision maker an overall understanding of the problem.

It is the effort of this paper to demonstrate that risk assessment should be considered an important step in pollution prevention. Techniques using data bases and computer programs are already available that can connect risk management and pollution prevention as part of the overall strategy to reduce hazardous waste.

Waste Minimization

Major environmental disasters, such as Love Canal in New York State and the dioxin sites in Missouri have sparked national attention and focused public and private interest on the problems of uncontrolled and improper waste disposal. The need to control hazardous waste led to the understanding that it is more difficult to clean up a spill then to prevent it from occurring. Cleanups are always difficult, many times ineffective, time consuming and always expensive. The initial response to environmental disasters was to prevent them from occurring by controlling pollution, and led to the creation of the Resources Conservation and Recovery Act (RCRA). RCRA significantly broadened the federal mandate for overseeing the generation, treatment and disposal of hazardous waste.

While the development of RCRA was clearly desirable, the impact of hazardous waste generation remained to be largely undefined. Trends in waste generation were inconsistent making decisions on costs and potential for waste reduction almost impossible. The development of the Hazardous and Solid Waste Amendment (HSWA) of RCRA in 1984 changed this problem forever.

Waste Minimization was, in fact, first introduced as a national policy in the HSWA. The EPA elaborated on the concept in its 1986 Report to Congress (EPA, 1986), stating that waste minimization is:

> "The reduction to the extent feasible, of hazardous waste that is generated or subsequently treated, stored or disposed of. It includes any source reduction or recycling activity undertaken by a generator that results in either (1) the reduction of total volume or quantity of hazardous waste, or (2) the reduction of toxicity of hazardous waste, or both, so long as such reduction is consistent with the goal of minimizing present and future threats to human health and the environment."

At present, there are three formal statutory requirements relating to waste minimization, all of them enacted as part of the 1984 amendments.

1. Section 3002(b) of HSWA requires generators to certify on their waste manifests (mandated under Section 3002 (a)) that they have in place a program "to reduce the volume or quantity and toxicity of such waste to the degree determined by the generator to be economically practicable."

2. Section 3005(h) of HSWA requires the same certification in relation to any new permit issued for treatment, storage, or disposal of hazardous waste.

3. Section 3002(a)(6) of HSWA requires, as part of any generator's biennial report to EPA, that the generator describe "the efforts undertaken during the year to reduce the volume and toxicity of waste generated" as well as "changes in volume and toxicity of waste actually achieved during the year in question in comparison with previous years, to the extent such information is available for years prior to enactment of HSWA."

These formal statutory requirements provide us with the data bases that are necessary to study trends and requirements to reducing waste. Still risk is not considered in the process. For example, EPA's Waste Minimization Opportunity Assessment Manual (EPA, 1988) outlines this fact rather clearly. Table 1 provides a list of the key elements for a successful pollution prevention program. Where in the frame work should risk be addressed or is it really necessary?

Table 1. Key Elements of an Effective Pollution Prevention Program

- Top Management Support
- Explicit Program Scope and Objectives
- Accurate Waste Accounting
- Accurate Cost Accounting
- Pervasive Waste Minimization Philosophy
- Technology Transfer

While the reporting requirements under HSWA have greatly increased our understanding of waste minimization activities, this information does not necessarily show the path towards additional pollution prevention. In the meantime, Section 313 of Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986 has made available new information related to the environment from certain manufacturing facilities. Also known as The Emergency Planning and Community-Right-to-Know Act of 1986, this law requires manufacturers to submit chemical-specific information on different types of environmental releases. Optional information on waste minimization actions taken to reduce these releases is also being required. The rest of this paper shows how this type of information can help us to assess the risk reduction associated with waste minimization.

Risk Assessment

Risk Assessments have become important to risk managers, policy makers, and the public in that they often offer a range of options, each having a specific cost and benefit. Properly conducted risk assessments have received fairly broad acceptance, in part because they put into perspective the terms: toxic, hazard, and risk (Paustenback, 1989). In pollution prevention, reduction in waste streams must be coupled with estimate of the magnitude and nature of the risks each stream imposes to health and the environment. If risk can be estimated, they can then be incorporated into the cost comparisons of different proposals to reduce waste. Without a good measure of risk, it is difficult to judge just exactly what benefits are received for the costs. In particular, it would be difficult to balance waste disposal options against waste stream reduction options. (Hahn, 1988).

In general, risk assessment has emerged as a major analytical tool in supporting environmental decision-making within EPA (North and Yosie, 1987). The growth in the use of risk assessment has resulted from EPA's need of increased sophistication in developing regulations mandated by laws, and improved way to communicate the scientific basis for decisions to the public. Risk assessment may be defined as the characterization of potential adverse effects to humans and the ecosystem resulting from exposure to environmental hazards. What risk assessment provides is an orderly, explicit, and consistent way to deal with scientific issues in evaluating whether a hazard exists and what the magnitude of the hazard may be. (North and Yosie, 1987).

Component of Risk Assessment
Discussing risk assessment, the National Research Council (NRC, 1983) divided the process of risk assessment into four components. These are:

1. **Hazard Identification** - consists of a review of relevant biological and chemical information bearing on whether or not an agent may pose a specific hazard.

2. **Dose-Response Assessment** - involves describing the quantitative relationship between the amount of exposure to a substance and the extent of toxic injury or disease.

3. **Human Exposure Evaluation** - involves describing the nature and size of the population exposed to a substance and the magnitude and duration of their exposure. The evaluation could concern past, current, or future exposures.

4. **Risk Characterization** - generally involves the integration of the data and the analysis of the first three components to determine the likelihood that humans will experience any of the various forms of toxicity associated with a substance.

The area of hazard identification and dose-response assessment are important components of risk assessment but are already derived for many of the major chemical analyzed in pollution prevention. In most situations it has been the toxicity side of risk assessment that has driven the reduction of waste in pollution prevention. The human exposure evaluation and risk characterization because of its site specific nature can change from location to location and from chemical to chemical. It's these two components of risk that are most important for using risk assessment in pollution prevention.

The assessment of human exposure involves an estimation of the number of people exposed and the magnitude, duration, and timing of their exposure. In some cases, it is straightforward to measure human exposure directly by measuring levels of the hazardous agent in the ambient environment. In most cases, however, detailed knowledge is required of the factors that control human exposure, including those factors which determine the behavior of an agent after its release into the environment. The following types of information are required for an exposure assessment:

- Quantities of an agent that are released and the location and timing of release.
- Factors controlling the fate of the agent in the environment after release, including factors controlling its movement, transformation, and degradation.
- Factors controlling human contact with the agent, including the size, nature and distribution of the population, and activities that facilitates or prevent contact.
- Patterns of human intakes. (EPA, 1989)

Availability of such information in many cases is limited, varies greatly from case to case, and may be difficult to accurately predict. Therefore, except in fortunate circumstances in which the behavior of an agent in the environment is unusually simple, uncertainties arising in exposure assessments could be significant. This situation is also different depending on whether the assessment is predictive or an estimate of risk is made on previous exposures. Once these various factors can be estimated, then chemical dose, its duration and timing, and the nature and size of the population receiving it are the critical measures of exposure for risk characterization.

The final step in risk assessment involves bringing together the information provided in the exposure assessment with toxicological data to determine risk. While the final calculations themselves are usually straightforward (exposure times potency or unit risk), the way in which the information is presented is important. For example, this step can be far more complex than indicated here, especially if problems associated with duration and/or timing of exposure are considered. Also, other factors such as the uncertainties which are introduced from assumptions and extrapolations must be considered. This discussion is a tremendous simplification of the risk assessment process, but is sufficient for the purposes here. The noncarcinogenic and the carcinogenic risks are the final measures of the possibility of human injury or disease from a given exposure or range of exposures.

Risk Assessment and Waste Minimization Data

When performing risk assessments, one must understand the sources, derive the exposure levels, determine human or environmental effects, and compute the risk. What the risk assessment provides in a pollution prevention setting is an orderly, explicit, and consistent way to deal with the scientific issues in evaluating whether a hazard exists and what will be the magnitude of hazard.

New data being made available to assist risk assessment includes: details of each hazardous waste stream being generated by industries; reports on each environmental hazardous substance being released; and information on the manufacturing processes and pollution prevention activities associated with both waste generation and environmental release.

These data elements provide the "source" in the risk assessment. Estimates of exposure levels (air, water and soil) can then be developed along with general or site-specific population information to create exposure scenarios. Appropriate toxic hazard data combined with the exposure estimates can then generate potential lifetime excess cancer risk or chronic non-cancer toxicity.

It is the final coupling of the data base with risk assessment techniques that will derive the overall picture of risk in pollution prevention. The following section outlines a simple approach, in most cases to get a better handle on risk reduction more detailed analysis should be performed. Table 2 summarizes the environmental discharge of benzene (lb/yr). In this example, benzene data is provided for years 1987 and 1988 to describe the changes in discharge from the statewide information. Also shown are the % change in discharge loading from 1987 to 1988.

Table 2. Benzene Discharge

	(lbs/yr)		
Type of Discharge	1987	1988	% change
Fugitive	502,010	320,576	-36
Stack	140,092	158,055	+13
Water	1,620	1,520	-6
Injection	0	0	---
Land	290	0	---
POTW	750	3,000	+300
Off-Site	65,903	39,350	-40
TOTAL	710,665	522,501	-26

The constituent of concern, benzene, was selected because of it's known carcinogenic properties. As part of the human exposure evaluation we have now developed a first-cut understanding of the quantities of an agent (lbs) and timing of release (yr).

The next phase of the risk assessment is to develop the factors controlling human contact and the patterns of human intake. Table 3 outlines the media and important routes of exposure of benzene.

Table 3. Media and Routes of Exposure

Media	Scenario (Routes of Exposure)	Cancer Potency Factor (1/mg/kg/day)
Groundwater	Drinking Water	2.9×10^{-2}
	Showering	2.9×10^{-2}
Surface Water	Drinking Water	2.9×10^{-2}
	Ingestion of Fish	2.9×10^{-2}
Soil	Inhalation of Particulates	2.9×10^{-2}
	Ingestion of Soil	2.9×10^{-2}
Air	Inhalation of Vapors	2.9×10^{-2}

The next step in the process is to develop the exposure scenario. Generic equations are used in calculating the resultant subchronic intake for inhalation and ingestion. Because we are not dealing with site specific information we are more interested in relative risk rather than actual risk. Relative risk in this case is how much risk increases or decreases by waste reduction from one year to the next. In this case study performing a risk assessment using only state wide data would give us meaningless risk values. The location of facilities, population distribution potential, human contact and fate of the chemical at each site could only determine a general risk value. By using relative risk values we bypass the questions associated with exposure scenarios on a state wide level.

Each route of exposure has associated with it an equation that determines estimated exposure (mg/kg/day). Again the discussion presented here is a simplification of the process and only the equation used for inhalation is provided.

General Exposure Equation for Inhalation

Potential inhalation intakes are estimated based on the number of hours in each event, the inhalation rate of the exposed individual during the event, the concentration of compound in the air breathed, the percentage absorbed into the bloodstream, and the body weight of the individual.

$$IEX = D \times I \times C \times RF \times 1/BW$$

WHERE: IEX = estimated inhalation intake (mg/kg/day)

D = duration (hr/day)
I = alveolar air rates of exposed person (M^3/hr)
C = compound concentration in exposure media (mg/M^3)
RF = % of inhaled compound absorbed into the bloodstream
BW = body weight of exposed person (kg)

For each route of exposure a similar equation is developed that calculates the resultant exposure. The resultant concentration is given in terms of mg/kg/day, when multiplied with the cancer potency factor (1/mg/kg/day) results in a unitless number and risk: If the result of inhalation exposure of benzene is 10-6 risk it means that one individual out of 1 million will likely develop an excess cancer due to exposure to benzene at a particular concentration under a unique exposure scenario.

It is important to note that risk assessment is not an exact science. The numbers developed are only estimates of what could likely occur. However as referenced in this paper they play an important role for decision making when attempting to balance cost and treatability in waste reduction.
The results of using risk assessment in this example are shown in Table 4.

Table 4 Relative Risk of Benzene 87-88

LOCATION	% CHANGE
on-site	-26
off-site	-3.7

The off-site also assumes that all the chemical is available to the environment. In most cases, off-site disposal of benzene is handled by incineration so in all likelihood the risk is significantly less than shown. The numbers generated from Table 3 and 4 only discusses risk via type of discharge point. However, when benzene is discharged to a POTW or off-site where does it really go? If we examine exposure by media assuming 90% of benzene available in the air, 9% in the water, and 1% in soil the following relative risk are computed in Table 5.

Table 5. Benzene Load by Media and Relative Risk

Media	1987	1988	% change
WATER	7,620	5,330	-30

SOIL	9,600	420	-56
AIR	702,089	516,746	-26

Exposure by media indicates potential risk in a different light. In all cases relative risk decreased, using a weighted average, by 26% from 1987 to 1988. The difference between using type of discharge versus media resulted in most of benzene getting into the air and changing the relative risk for both on-site and off-site conditions.

Combining Waste Minimization and Risk Assessment

By looking at waste minimization in terms of Table 2, pounds per year, we are limiting our capabilities in understanding what is truly occurring at a site. In many cases, a constituent will behave differently in different media. For example, if we used arsenic instead of benzene, the cancer potency factor would be different for inhalation exposures versus ingestion by an order of magnitude increase. This would imply that an inorganic compound such as arsenic is more important to reduce in air rather than as a contaminant in soil or sludge. Relative and actual risk by media (Table 5) would then be significantly different.

With the addition of high powered personal computers the combination or addition of risk assessment with waste minimization options is presently achievable. Tools such as EPA's RISK • ASSISTANT (Segna and Walentowicz, 1989) can provide the computer system for conducting the exposure and risk aspects of the problem. The whole idea is to eventually combine risk, cost, and technical capabilities in a computerized format that will not only generate waste reduction but more important risk reduction as well.

Figure 1 illustrates the point in simplistic fashion. An industrial facility has a number of chemicals it must attempt to reduce as waste.

In the past, cost was the driving force in getting most removal (regardless of media) to meet State requirements for waste minimization. With the use of a data base system coupling cost and treatment considerations one can get a first cut in reduction in waste. The next step is to add a risk assessment module to understand what benefits can be achieved under that particular scenario. By adjusting cost and treatment one can see if risk also changes significantly. It can be quite possible that total % reduction in waste does not equal an equivalent reduction in risk.

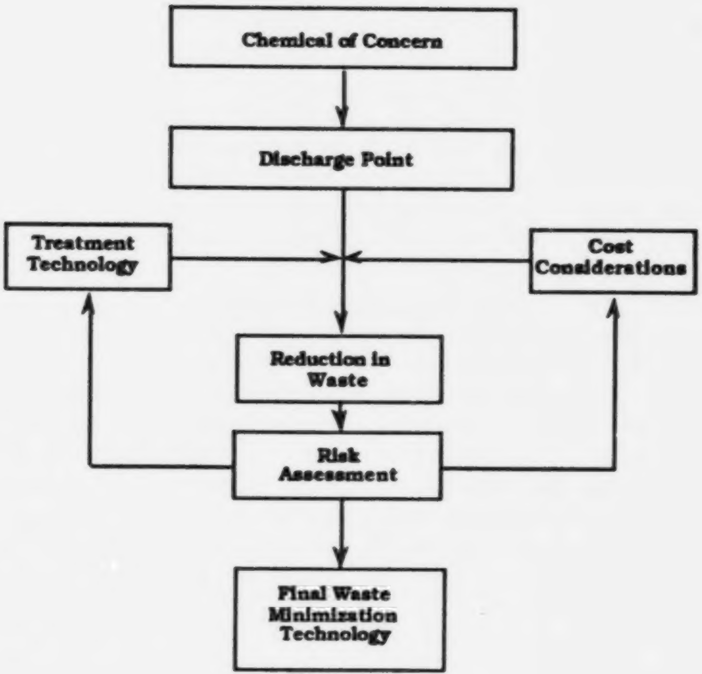

Figure 1

Conclusion

Pollution prevention based solely on economic, technical or regulatory decisions could be misleading. Approaches that tie-in risk reduction to pollutant prevention must be considered in any decision making process. The approaches discussed in the paper could provide a user and decision-maker with the tools they need in determining pollution prevention technologies.

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Educational Aspects of Multimedia Pollution Prevention

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Introduction

Environmental quality and natural resources are under extreme stress in many industrialized nations and in virtually every developing nation as well. Environmental pollution is closely related to population density, energy and transportation demand, land use patterns as well as industrial and urban development. The main reason for environmental pollution is the increasing rate of waste generation in terms of quantity and toxicity that has exceeded our ability to properly manage it. The other reason is the management approach that has focused on media-specific and "end-of-pipe" strategies, even though a media-specific approach has improved our environmental quality to a certain extent. There is increasing reported evidence of socio-economic and environmental benefits realized from multimedia pollution prevention.(1,2) The prevention of environmental pollution in the 1990s is going to require not only enforcement of government regulations and controls, but also changes in manufacturing processes and products as well as in lifestyles and behavior throughout our society. Education is key in achieving the vital goal of multimedia pollution prevention.

This paper presents a broad-based approach to promote environmental education and training in the principle and practice of multimedia pollution prevention. It illustrates some significant issues that need to be addressed including environmental problems, the cross-media nature of pollutants, benefits of multimedia pollution prevention, and the importance of education and training. The purpose of this paper is to stimulate open discussion of educational needs necessary to meet the environmental challenge of the 1990's and beyond. The challenge is how to integrate air-water-land pollution management through waste prevention prior to the application of waste treatment and disposal techniques.

Environmental Problems

Environmental problems result from releases of wastes (gaseous, liquid, and solid) that are generated daily by people from industrial and commercial establishments, as well as households. The lack of consciousness regarding conservation of materials, energy, and water has contributed to the wasteful habits of our society. The rate of waste generation has been increasing in accordance with the increase in population and the improvement in living standards. With technological advances and changes in lifestyle, the composition of waste has likewise changed. Chemical compounds and products are being manufactured in new forms with different half-lives. It has been difficult to manage such compounds and products once they have been discarded. As a result, these wastes have caused many treatment, storage, and disposal problems.

Many environmental problems are caused by products that are either misplaced in use or are discarded without proper concern of their environmental impacts. Essentially all products are potential wastes, and it is desirable to develop methods that reduce the waste impacts associated with products, or to produce environmental friendly products. Environmental agencies have been lax in promoting and automating tracking mechanisms which identify sources and fate of new products.

Solving problems, however, can sometimes create problems. For example, implementation of the Clean Air Act and Clean Water Act has generated billions of tons of sludge, wastewater, and residue that could cause soil contamination and underground water pollution problems. The increased concern over cross-media shifts of pollutants has yet to translate into a systematic understanding of pollution problems and viable changes in regulatory designs.

Environmental protection efforts have emphasized media-specific waste treatment and disposal after waste has already been created. Many of the pollutants which enter the environment are coming from "area sources" such as industrial complex and land disposal facilities; therefore, they simply cannot be controlled by the end-of-pipe solutions. Furthermore, end-of-pipe controls tend to shift pollutants from one medium to another and cause secondary pollution problems. Therefore, for pollution control purposes, the environment must be perceived as a single integrated system and pollution problems must be viewed holistically. Air quality can hardly be improved if water and land pollution continue to occur. Similarly, water quality cannot be improved if the air and land are polluted.

Many secondary pollution problems today can be traced in part to education, i.e., the lack of knowledge and understanding of cross-media principles for identification and control of pollutants. Neither the Clean Air Act nor the Clean Water Act enacted in the early 1970's adequately addresses the cross-media nature of environmental pollutants. More environmental professionals now realize that our pollution legislation is too fragmented and compartmentalized. Only proper education and training will re-orient this situation and will hopefully lead to a more comprehensive legislation of the total environmental approach.

Multimedia Approach

The environment is the most important component of our life support system. It is comprised of air, water, soil, and biota through which elements and pollutants cycle. The cycle involves the physical, chemical, or biological processing of pollutants in the environment as shown in Figure 1. It may be short, turning hazardous into non-hazardous substances soon after they are released; or, it may continue indefinitely with pollutants posing potential health risks over a long period of time. Physical processes associated with pollutant cycling include leaching from soil to groundwater, volatilization from water or land to air, and deposition from air to land and water. Chemical processes include decomposition and reaction of pollutants to products with properties that are possibly quite different from those of the original pollutants. Biological processes involve micro-organisms which can break down pollutants and convert hazardous pollutants into less toxic forms. However, they can also increase the toxicity of a pollutant, for instance, by changing mercury into methyl-mercury in soil.(3)

Although pollutants sometimes remain in one medium for a long time, eventually they will move. Pollutants settled in river sediments can be dislodged by micro-organisms, flooding, or dredging. Displacement such as this constituted the PCB problem in the New York State Hudson River. Pollutants placed in landfills have been transferred to air and water through volatilization and leaching. About 200 hazardous chemicals have been found in the air, water, and soil at the Love Canal land disposal site in New York State. The advantages of multimedia approaches lie in their ability: (1) to manage the transfer of pollutants so that they will not continue to cause pollution problems, (2) to avoid duplicating efforts or conflicting activities, and (3) to save resources by consolidation of environmental regulations, monitoring, database management, risk assessment, permit issuance, and field inspection.

In recent years, the concept and goals of multimedia pollution prevention have been adopted by many regulatory and other governmental agencies, industries, and the public in the United States and abroad. Multimedia efforts in the United States have been focused on by the U.S. Environmental Protection Agency's (USEPA) Pollution Prevention Office which helps coordinate pollution prevention activities across all USEPA headquarter offices and regional offices. The current USEPA philosophy recognizes that multimedia pollution prevention is best achieved through education and technology transfer rather than through regulatory imposition of mandatory approaches. But the progress of implementing multimedia pollution prevention has been slow.

Recognition of the need for multimedia pollution prevention approaches have extended beyond the government, industry, and the public, to professional societies. The Air Pollution Control Association (APCA) has been renamed as the Air and Waste Management Association (AWMA) to incorporate waste management. The American Society of Civil Engineers (ASCE) has established a multimedia management committee under the Environmental Engineering Division. The American Institute of Chemical Engineers (AIChE) has reorganized its Environmental Division to include a section devoted to pollution prevention. The Water Pollution Control Federal (WPCF) has adopted a set of principles addressing pollution prevention.

Pollution Prevention

President Bush, in signing his first proclamation of the new decade (the 20th Anniversary of the Earth Day Proclamation) declared, "We must...seek solutions that embrace all sectors of society in preventing pollution and ecological damage before they occur." The USEPA's Administrator William Reilly also said, "We must start preventing pollution as the primary means of meeting our environmental objectives." The USEPA's policy has focused on pollution prevention via the multimedia reduction of pollutants at the source and the promotion of environmentally sound recycling. A major goal of Earth Day 1990 has been to encourage government agencies to acknowledge the importance of pollution prevention.

Pollution prevention approaches for environmental protection include:

(1) Reducing the quantity and/or toxicity of pollutants generated by production processes through source reduction, waste minimization, and process modification.

(2) Eliminating pollutants by substituting non-pollutant chemicals or products (e.g., material substitution, changes in product specification).

(3) Recycling of waste materials (e.g., tracking by-products, reuse, reclamation).

Source reduction is the key component of multimedia pollution prevention strategies. It acts as the first line of defense against the ever-increasing quantity and toxicity of waste which poses environmental pollution problems. Source reduction is not simply a means of environmental protection, but part of the broader picture of industrial process and products improvement, modernization, innovation, and expansion. It is considered one of the least costly means of waste management and also provides one of the best means of pollution control. Source reduction can conserve expensive materials and save not only in the direct costs of waste management (storage, transport, treatment, and disposal) but also in the administrative costs of regulatory compliance, legal advice, liability insurance of long-term environmental risks and managerial time. However, many available opportunities in source reduction and recycling have not been pursued, simply because many waste generators are not aware of such opportunities. Therefore, the key to successful implementation of pollution prevention is education and technology transfer.(4)

Pollution prevention design consists of several multimedia elements. These range from complex scientific and technological considerations to major socio-economic factors, public policy and regulatory issues. Waste reduction through a further extension of sound operating practice appears most promising. It includes, such techniques as employee training, management initiatives, inventory control, waste stream segregation, scheduling and material handling improvement, spillage and leakage prevention, and preventive maintenance.

The next promising area for source reduction is technological modification of continuous processes that generate large amounts of waste. Input material substitution and new product designs can be highly effective in processes where impurities constitute a considerable faction of input material or where the potential exists for lowering the toxicity of auxiliary raw material. Product substitutes to reduce waste generation can be effective, but it is an extremely complex issue. For example, a substitute must provide the same function as, or a better function than the original product; the waste characteristics associated with the substitute's manufacture and disposal must compare with that of the original products; and the increased costs of a substitute must be compatible with net environmental benefits and a free market economy.

Both internal and external influences stimulate the integration of pollution prevention in corporate management. Internal influences refer to economic advantages, workers' demands for cutting down occupational exposure risk and development in environmentally acceptable products and processes. External influences include regulations, public opinion, concern about environmental degradation, as well as technical and financial assistance programs.

Elements of an effective pollution prevention program for industries and government agencies should consist of goals, organization, commitment, resources, and communication. Success in pollution prevention requires "incentives". Waste generators must have economic reasons to implement waste minimization and clean technology options in their daily operation. Economics is the driving force for most business decisions, and pollution prevention should provide incentives to achieve environmental quality goals.(5)

Education and Training

The role of environmental professionals in waste management and pollution control has been changing significantly in recent years. Many talented, dedicated environmental professionals in academia, government, industry, research institutions, and private practice need to cope with change, and to extend their knowledge and experience from media-specific, "end-of-pipe", treatment-and- disposal strategies to multimedia pollution prevention management. The importance of this extension and reorientation in education, however, is such that the effort cannot be further delayed. Many air pollution, water pollution, and solid waste supervisors in government agencies spend their entire careers in just one function because environmental quality supervisors usually work in only one of the media functions. Some may be reluctant to accept such an educational extension and re-orientation. This is understandable given the fact that such a re-orientation requires time and energy to learn new concepts and that time is a premium for them. They must, nevertheless, support such education and training in order to have young professionals well-trained.

Successful implementation of multimedia pollution prevention programs will require well-trained environmental professionals who are fully prepared in the principles and practices of such programs. The programs need to develop a deep appreciation of the necessity for multimedia pollution prevention in all levels of society that will require a high priority for educational and training efforts. New instructional materials and tools are needed for incorporating new concepts in the existing curricula of elementary and secondary education, colleges and universities, and training institutions. The use of computerized automation offers much hope. Government agencies need to conduct a variety of activities to achieve three main educational objectives:

1. Ensure an adequate number of high-quality environmental professionals,
2. Encourage groups to undertake careers in environmental fields and to stimulate all institutions to participate more fully in developing environmental professionals, and
3. Generate data based which can improve the environmental literacy of the general public and especially the media.

These objectives are related to, and reinforce, one another. For example, improving general environmental literacy should help to expand the pool of environmental professionals by increasing awareness of the nature of technical careers. Conversely, steps taken to increase the number of environmental professionals should also help to improve the activities of general groups and institutions. Developing an adequate human resources base should be the first priority in education. The training environmental professionals receive should be top quality.

There is a significant need to provide graduate students with training and experience in more than one discipline, as many of the most important and interesting environmental scientific and technological questions increasingly require interdisciplinary or multidisciplinary approaches. Environmental graduate programs must address this aspect. Most practicing environmental professionals face various types of environmental problems that they have not been taught in universities. Therefore, continuing education opportunities and cross-disciplinary training must be available for them to understand the importance of multimedia pollution prevention principles and strategies, as well as to carry out such principles and strategies.

The education and training plan of multimedia pollution prevention may be divided into technical and non-technical areas. Technical areas include:

1. Products -- Life cycle analysis methods, trends-in-use patterns, new products, product life-span data, product substitution, and product applicability. A product's life cycle includes its design, manufacture, use, maintenance and repair, and final disposal.

2. Processes -- Feedstock substitution, waste minimization, assessment procedures, basic unit process data, unit process waste generation assessment methods, materials handling, cleaning, maintenance and repair.

3. Recycling and Reuse -- Market availability, infrastructure capabilities, new processes and product technologies, automated equipment and processes, distribution and marketing, management strategies, automation, waste stream segregation, on-site and off-site reuse opportunities, waste exchange opportunities, close-loop methods, waste recapture and reuse.

Non-technical areas include:

1. Educational programs and dissemination of information,
2. Incentives and disincentives,
3. Economic costs and benefits,
4. Sociological and human behavioral trends, and
5. Management strategies including coordination with various concerned organizations.

Environmental professionals dedicated to multimedia pollution control also need to have a broad education and sound understanding of:

1. characteristics of pollutants in waste streams;
2. cross-media nature of the movement, distribution, fate, and effect of pollutants that have entered the environment;
3. coordinated management of gaseous, liquid, and solid wastes so problems are not shifted unduly from one medium to another;
4. use of source reduction and recycling prior to waste treatment and disposal;
5. environmental impact and cost-effectiveness of solutions;
6. intelligent and automated information and data management systems;
7. role of ethics in decision-making;
8. societal system such as current environmental laws and regulation;
9. environmental sociology, public relations, and communications; and
10. use of risk assessment and management tools.

Though the subject matter to be covered is broad, the environmental profession will not be well served by training only generalists. Beyond the basic goals and within specific areas listed, it is important that for most professionals to obtain some degree of specialization. Environmental professionals should learn broadly and act specifically with full knowledge of the impact of ones actions.

Education and training can take many forms: new curriculum materials in our primary and secondary schools, new courses and degrees in our universities, new business practices by our corporation, and new local and national legislation by our policy-makers. Societal change away from our current "end-of-pipe" command-and-control practices and toward a more pollution preventive strategies will only evolve through proper education and training throughout all levels of the society. The need for educated and trained personnel in multimedia pollution prevention is urgent. The lack of trained professionals impedes the implementation of pollution prevention program. Computer literacy must also be elevated to transfer existing expertise for ready access by junior professionals.

The universities and training institutes must make a substantial effort to revise their teaching materials to adequately cover topics of great importance to environmental problems and possible solutions through waste reduction, recycling, and clean technologies. Environmental professionals in industries and consulting firms are likely to examine environmental problems that involve all media. Industrial pollution control problems typically involve consideration of liquid, gaseous, and solid wastes, so excellent opportunities exist for both cross-media analysis and integrated design of waste treatment systems. Effluent and emission standards can be related to toxicological information in the environment. Exposure estimates, risk assessment, safety, reliability, and fail-safe designs can be incorporated into the training. Recently, training manuals have been published as a tool for the identification and assessment of pollution prevention options at a plant level.(6,7) The government and the educational system must conduct more workshops, seminars, conferences, and outreach efforts as well as establish more information clearinghouses on multimedia pollution prevention with respect to methodologies and technologies. The teleconferences with remote hookup for dialog are also useful in transfer of detailed information and skills.

A new environmental ethic must be taught in universities and continuing education with an understanding of the effect that development of new clean technologies and new products is essential for environmental protection. For example, industrial plants have usually been developed to maximize reliability, productivity, product quality, and profitability with chronic emissions and effluents, waste treatment and disposal being secondary factors. Engineers and managers in those plants must be educated to take a proactive role in design and operation that produce less waste, less toxicity of the waste, and to improve ability to predict the fate of pollutants in the environment after release. Waste generators must accept the responsibility for meeting the total costs of the production of goods and services. The traditional market prices have not reflected subsequent costs of waste disposal nor the uncompensated environmental and health damages. Thus, the responsibility of waste generators must go beyond those for production and marketing to social costs as well. All waste generators should follow "The Valdez Principles" of ethical guidelines for protection of the environment.

Effective public education including media is essential to any type of program. Public opinion, public awareness and public participation will fuel the entire multimedia pollution prevention effort. For example, developing public support up front will develop public demand for pollution prevention and for products manufactured via clean technologies. If products are not purchased, industry will stop producing them. Public attitudes must be changed via education first.

Environmental regulatory agencies should support the development and implementation of education and training programs that teach targeted groups about methods and procedures to prevent pollution problems. They also should work with private industry and universities to incorporate environmental studies and training into academic curricula. Students who study business, science, engineering, public policy, law, economics and medicine should all be exposed to the concept of multimedia environmental pollution and the clean techniques of pollution prevention.

Conclusions

Industrial and urban growth, energy and transportation demand, land use patterns, and wasteful habits have all created environmental problems as well as challenges. Part of the answer to these challenges lies in education and training to develop new multimedia pollution prevention policy and legislation. Education and training would create practical solutions that would shift environmental management strategies from passive/reactive restoration to preventive planning. This would allow sustained economic growth while minimizing environmental damage.

Success of implementing multimedia pollution prevention programs will require an adequate number of well-trained environmental professionals and a fundamental shift in attitude and perception. This shift is unlikely to occur without an aggressive and proactive program of education. The lack of well-trained environmental professionals impedes a viable approach to environmental protection via pollution prevention as much as funding limitations do. Computer science techniques must be expanded to include ethical evaluation of environmental costs when evaluating the consequences of planned activities.

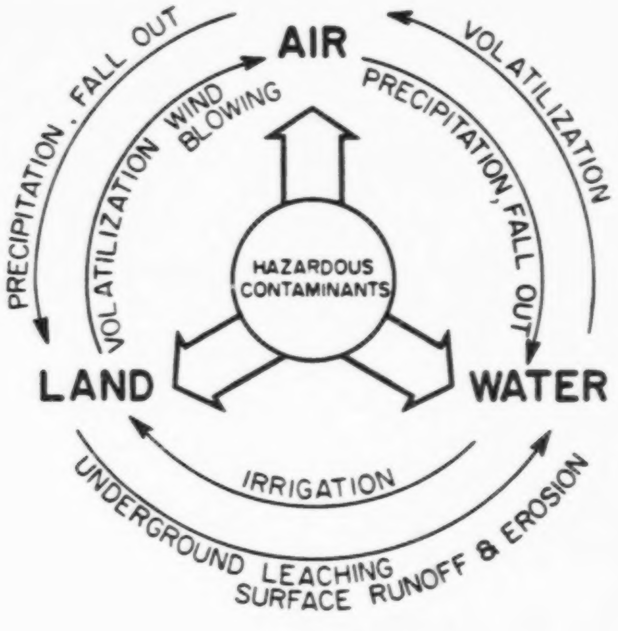

Fig. 1 HAZARDOUS CONSTITUENT CYCLE

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Industrialization, Development and the Environmental Crisis in Developing Economies of the Caribbean Basin Region

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Abstract

Introduction

Fragile Caribbean island economies, struggling to modernize their largely plantation economies and in many cases attempting to reduce their single export item dependency, are trying to industrialize and diversify. Modernization and development have resulted in the proliferation of sanitary landfills and waste dumps. The process has resulted in increased faecal pollution of water courses, coastal wetlands and marine preserves. Their haste to increase crop yield and reduce post harvest loses has meant a decided and almost suicidal turn to insecticides, pesticides, fungicides and germicides.

Methodology

Many of the older technologies such as oil extraction and refining, mining of bauxite, manufacture of cane sugar and rum have polluted the once pristine environment, the envy of European tourists.

Recent attempts to harness the newer technologies, metal plating, plastics, etc., have left the environment in crisis. Technology transfer packages with guilt edged commitments have opened the Pandora's box. These demands have proved too much for the weak technology resources of these islands' economies.

New terms loom large on the horizon as the island leaders seek to woo foreign investors. The seemingly attractive package includes the highly toxic industries under containment by the US EPA and its European equivalents, looking for more favorable industrial climate to resume operation of the latest of the growth industries, treatment of toxic and hazardous waste. To this must be added the recent reports of environmental pollution created by clandestine of hazardous chemical waste and the requests to develop dumping sites in these micro states. The question is how can these island states protect themselves. The paper reviews the Caribbean experience and develops a tri-partite strategy that can be adopted by the coordinated efforts of Caribbean agencies charged with environmental surveillance and protection, the United Nations agencies and US EPA.

Conclusions

The paper discusses the arguments for technology transfer which are in essence contracts between unequal parties. It concludes with a discussion on three important concepts:

(a) The Technology transfer question and the "Beggar cannot be Chooser" concept.
(b) Ethics and the International Environmental Question.
(c) What can be done to help developing countries from destruction.

Industrialization, Development and the Environmental Crisis in Developing Economies of the Caribbean Basin Region

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Introduction

Caribbean Island States do not now have deeply rooted industrialized economies but without exception have come to the realization that this is a necessary, even if belated, path to their development. Desperate efforts to modernize and diversify national economies have correctly identified strategies which call for entering new areas of activity and thereby break the stranglehold dependence on their entrenched mono-sectoral economies. National economic planning strategies all shared certain common features:

(a) Weak technological infrastructure
(b) Most of the islands can only lay claim to any technical experience in sugar refining and rum manufacture. This is with the exception of Jamaica with at least three (3) decades of Bauxite industry and Trinidad with Petroleum industry that is more than six (6) decades old.
(c) Only a recent concern with environmental issues.
(d) All are presently engaged in developing industrial plans and are in the quest for international capital to take up the leadership in implementing an industrialization plan.
(e) Most of the islands would have a very weak legal machinery to deal with technology, the environment or pollution control.

To describe their position as vulnerable is an understatement since they have no alternative but to turn to foreign capital, foreign technology and to foreign advisors to take them into the twenty-first century.

The paper will not dwell on the state of underdevelopment but will develop the basis of the environmental crisis as it now exists and as it already is developing. It will concentrate on what the author sees as the path forward and offer mechanisms for dealing with the otherwise inevitable environmental degradation of the Robinson Cruiso type islands.

Early Industrialization

Early industrialization in rum distillation and manufacture and sugar production would have resulted in crop-time inconvenience occasioned by the burning of the canes before harvesting. The grinding of the canes and the subsequent processing would have had to utilize a generous quality of potable water. The waste water, the product of washing, would have been allowed to empty into natural streams and rivers or into the coastal water where the refineries were situated near the coast. The product generates a stench as well as floating scum. Because of the importance to the island economies and the relative influence of the industry' operation, pollution was considered a necessary evil with which one simply had to live. The issue may have been dismissed as suicidal to the industry which was already struggling for survival against beat sugar, artificial sugars, cane sugar production in areas where mechanization was well advanced and the economies of scale provide too much for Caribbean producers.

In the case of Trinidad, in excess of pollution from the sugar industry the economic blessings of petroleum were accompanied by pollution of the lands as a result of exploration and production wells. Several streams have become biologically dead because of waste and spills coming form the refinery operations. Marine exploration which began in 1954 saw the beginning of coastal pollution and gradual destruction of wetlands and even loss of certain beach (bathing) areas to bilge washing from boats, oil spills and simple discharge of waste from coastal refineries and motor vehicles.

Although Trinidad and Tobago is not a producer of bauxite, a trans-shipment port has been constructed in Trinidad to receive the bauxite from the river going boats which come from neighboring Guyana. The villages around the trans-ship port have repeatedly protested about the bauxite dust that has discolored their homes and clothes and which has posed a health risk to all residents. The problem has not yet been dealt with.

In a previous document the author (1) has discussed the earlier stages of industrialization that have ocurred in Trinidad and Tobago. It was pointed out that in the last two decades several small industrial estates have been set up with a wide range of chemical process and manufacturing operations. The effluent from these factories has been allowed to enter roadside drains, streams and rivers. These ultimately pour into the coastal areas destroying the wetlands and the life forms native to them. The coastal marine life forms have taken a heavy beating.

Industrialization and urbanization have brought with them increased population concentration and higher levels of domestic sanitation. Central sewerage and packaged treatment plants have virtually mushroomed in each new housing estate, in each new industrial or manufacturing estate. The sad fact is that inevitably the malfunction resulting in atmospheric pollution (stench) and faecal waste or partially untreated sewerage are allowed to enter water courses. Like with petroleum pollution the land becomes polluted, the streams and coastal waters become polluted and ultimately gravity and percolation means that contamination enters the ground water system of wells and aquifers.

Sanitary landfills have quietly polluted the land and with the passage of years finally the pathogens, the dissolved heavy metal and metallic salts and other chemical pollutants have finally appeared in the aquifers which once were the source of pure water.

The present interest in accelerating and deepening the industrialization process is occurring in an environment where pollution has not been a topic for economists nor planner, where industrial disasters have not yet entered the planning equation. We have not yet learnt to treat with existing industrial pollution. We have not set in place the necessary legislation neither the necessary institutions (2). While we cannot hold back the proverbial march of progress, we must now be abundantly clear that all these must be put in place on an accelerated agenda. If we do not, new sources and new forms of pollution will visit the region with the inevitable new thrust in industrialization. The question of industrial pollution has assumed a new dimension where several multi-nationals begin a quest for sites within the non-developing countries to dispose of hazardous and toxic waste and in a few cases even to set up factories ostensibly to detoxify or neutralize hazardous and toxic waste. These implications have been discussed by the author in a previous paper (3) and will not be dealt with here.

The Nature of the Crisis

One may begin by presenting the dilemma of the industrial planner. It is generally felt that industrialization holds the secret to the non-development of Caribbean countries. some have advanced this as a strategy well worth embracing by all the non-developing countries. As we are no doubt wiser by the mobilization of the Green Peace Organization in Europe and the green movement internationally, by the outstanding work which emanated in the United Nations General Assembly during 1990's the Decade of Natural Hazard Reduction, by the timely though unfortunate catastrophies of Bhopal, Three Mile Island, Chernobyl and Exxon Valdeze by the growing awareness of desertification and consequent famine in Sub-Sahara Africa, by the lead work of TIME Magazine in its January 2/89 Issue - "Endangered Earth" and its continuous articles together with the rest of the international media on such topics as, Global Warming and the Greenhouse Effect; Ozone Depletion, the Threat to the Tropical Rain Forest, Toxic and Hazardous waste, Acid Rain, Sanitary Landfills and the Pollution of Aquifers and Oil Spills and Dumping of Waste at sea. We are now fully aware of the negative impact of industrialization on human life and the degradation of the environment.

We cannot plead but culpable ignorance. This is the dilemma which planners face armed with the promise of the plusses and the certainty of the minuses. How is he to maximize the benefits? In the face of this crisis several comments must be dealt with.

(i) "Appropriate Technology is less polluting".

This would caution against too rapid an assimilation of the so called "high technology of the developed world. The corollary must be that high technology is inherently polluting. There is the danger that if for no other reason, non-developing countries in being relegated to low or appropriate technology will never be able to compete with the developed countries and not only the technology gap will widen but the development gap as well. This thesis that high technology is necessarily more polluting will not be dealt with here neither will the complementary argument that so called "appropriate technology" is more suited to non-developed countries. In fact the author is firmly convinced that the non-developing countries can only enter into the development of the twenty-first century on the work horse of technology.

(ii) "Any attempt to formulate a serious package of laws and guidelines to treat with industrial accidents and disaster preparedness would discourage foreign investors and even the local ones as well".

The argument here is that to put the necessary safe-guards, training programme and insurance in place will increase cost to the investor. No one points out that increase safety and disaster preparedness will set the environment for greater efficiency, innovation, commitment and consequently greater productivity. These conditions must lead to better industrial relations, less down time, less rejects, less loss of time due to accidents and hence higher output. This is possibly the simple reason why proposed improvement to the Factories Act (1950), "The Act Representing the Safety, Health and Welfare of all persons in relation to the activities of industrial establishment", has languished in the corridors of parliament and the drafting department since 1984. It may indeed explain why the Public Health Act, Chapter 12 No. 4, Laws of Trinidad and Tobago 1950 Edition, has been redrafted several times but has not yet been repealed and replaced.

(iii) "That the non-developing countries are the industrial haven for 'dirty technology'".

There is much evidence that would support that several multinationals involved in highly polluting, highly toxic and hazardous products have in recent years (the decade 1980's) sought to transfer operation to several non-developing countries. This may explain why they have sought to clandestinely dispose or dump hazardous and toxic waste (chemical sludge and radioactive waste as well known) in the Caribbean Basin Region.

It is not a haven for the regional environmental groups have already been made aware. The population has been alerted although the risk has not disappeared.

(iv) "The Economists have not yet addressed the environmental question".

The most glaring support of this view is that environmental impact statements are not necessary or demanded as a necessary precondition of all industrial, commercial or residential projects. It is therefore reasonable to assume that many developments which are carried out without the benefit of environment impact assessment studies.

Regional Economists have not yet got into the question of assessing the economic effects of natural or man made disasters far less the environmental degradation and pollution. Frantic efforts are not being made to draw them into the discussion. We often get an accounting statement of market value for buildings and crops lost but the analysis of the impact on the long term development has not yet begun. Several non-economists including the author hold the view that the destruction by natural disasters constitute a big factor in the non-developing of the so-called non-developing countries.

(vi) "The State should assume responsibility for effecting industrial clean up after disasters".

It has been argued that companies pay taxes to help defray cost of clean up and recovery, and that the burden for clean up should be assumed not by the industrial polluters and the author of the disaster but that the state, representing all the citizenry, should carry financial responsibility. The argument has been advanced that this should be undertaken as a sort of incentive. Indeed one can understand the position of the state in entering into clean up where:

(i) An industry has been polluting an area for a long period and the clean up process would result in the company becoming bankrupt. The state may assist in this case

(ii) The industry that created the pollution is no longer in existence

(iii) The particular industry is critical to the economy and does not have the technical or financial capacity to undertake clean up by itself.

Industry should be encouraged by all means available to convert to clean technologies. This could possibly generate tax relief and/or assistance to those that move to put in place clean technologies. Incentives to clean up must be linked to incentives to convert to clean technologies and to enter into recycling and reduction of waste.

We must also understand the nature of the principal forces driving the crisis in non-developing countries.

One of the major driving forces in the quest for new parcels of arable land, in order to support rising population and to generate surplus for export. The problem had also been exercerbated by unscientific farming practices which have resulted in net loss and degradation of existing agricultural land. In the Caribbean islands hillside "slash and burn", which has been increasing a pace, has meant loss of hillside forest cover. Erosion has ensured that the recently exposed area will only serve for two or three years and the farmer must move on, "slash and burn" more forest, increase erosion and flooding in the low lying areas. In rural areas where wood is used as fuel, felling of the forest goes on. The de-forestation process is therefore driven by the need for fuel as well as to yield land for planting. The consequence is not environmental pollution per se, but environmental degradation since both the hillsides and the flooded areas are degraded and ultimately can yield less and support less life.

Another driving force in the environmental crisis is the increased use of artificial (chemical) fertilizers, insecticides, pesticides, fungicides and herbicides. Driven to obtain better yields and in many cases to prevent dwindling yields on exhausted lands farmers have turned to chemicals. The results in Trinidad and Tobago, while promising in volume yield have been very discouraging in other areas. Mounting incidence of accidental poisoning in rural agricultural homes among children, accidental poisoning among farmers who are either not properly trained in the use of the chemicals and not aware of the toxicity risk, a rise in disease occasioned by prolonged exposure to low doses of toxic chemicals. While no serious published results of tests are available it is generally felt that the crop yield is compromised with these poisonous chemicals which accumulate in the human body. The issue has been so serious that finally the "Pesticides and Toxic Chemicals Act, No. 42 of 1979" had to be put on the books.

We must mention the mushrooming of industrial estates and separate cottage type industrial operation since the period 1970's. This small scale industrial effort which began in the post independence era (1962 -) saw the proliferation of these un-monitored or un-controlled ventures. The 1974 rise in oil prices saw some inflow of money and increase in those manufacturing ventures. No one considered restraint. The Factories Inspectorate did not increase its technical competence to monitor or regulate industry and no one thought this was a necessary function, definitely not the industrial planners nor the politicians. No legislative reform or updating took place in respect of industrial safety or the protection of the environment although we focused on tax reforms. The Factories Act saw very little reform of significance. The Public Health Ordinance remained unchanged in spite of countless new drafts having been prepared. Clearly this was not within the focus of the parliament or the planners.

In recently prepared review (4) by the author the conclusion was made that the legislative mechanism which dealt with industrial accidents, industrial pollution and industrial disaster preparedness was all but dormant in the decades of 1970's and 1980's. Of the Bills that reached parliament only a few emerged law and of these the necessary organizational support staff and funding were so deficient that very little was achieved. The main legislative banner may have been the Litter Act (Chapter 30:50, Act 27 of 1973, later amended by 2 of 1976). It was an Act "respecting the littering of public places and of premises", as the short title reads. The Act made provision identifying offences and penalties for littering. It gave the local authorities power to enforce removal of litter, power to enter and inspect premises and to remove derelict vehicles left in any public place. Finally it made provision for the setting up of wardens to assist in carrying out the functions conferred on the local authority by the Act. It is not with any satisfaction that one notes that the Act did not achieve what its drafters may have intended. The problem lay more with the commitment to enforcement and persecution.

We must note that the environmental question was identified as an important one even if it did not receive its due.

The previous regime did set up the Solid Waste Management Company, a State owned company to handle the management of garbage collection, transportation, and disposal, the question of sanitary landfills and garbage dumps, the collection of sewerage and even some industrial waste.

The Institute of Marine Affairs prepared a compilation of laws regulating the use of the coastal environment (5). This research report begins, "Environmental Law as a judicial corpus or distinct branch of the Law is in its infancy in Trinidad and Tobago, indeed in many countries of the world". The report goes on to state that, "The time is perhaps right therefore, to examine those laws which have the capacity to control the manner in which we use our resources and the activities associated with this exploitation". While the main reason for the compilation was the Coastal Environment, it lists as well all the laws that impact on the environment under the broad headings.

Classification:

1. Laws
    - A. Legal
        - Administrative Law
        - Penal Law
        - Civil Law
        - International Law
    - B. Environmental
        - Water Pollution
        - Air Pollution
        - Noise Abatement
        - Waste Disposal
        - Nature Conservation
2. Statutes
    - A. Legal
        - Constitutional Law
        - Administrative Law
        - Penal Law
        - International law
    - B. Environmental
        - Water Pollution
        - Air Pollution
        - Noise Abatement
        - Waste Disposal
        - Nature Conservation

In fact it will not be correct to say that very little legislative work was done in the last three decades in the area of environmental control and protection. Any serious discussion must begin with the Town and Country Act, Chapter 35:01, previously Act 29 of 1960 (amended by 13 of 1974 and 19 of 1977). This Act sought to "make provision for the orderly and progressive development of land in both urban and rural areas and to preserve and improve the amenities thereof; for the grant of permission to develop land and for the powers of control over the use of land; to confer additional powers in respect of the acquisition and development of land for planning; and for purposes connected with the matters aforesaid".

This is the basis of all development and a guide to all environmental protection plans. The problem therefore is not absence of legislation but rather the will to enforce these legislation.

In 1986 a new government was elected and in 1987 a national clean up campaign was launched in which attempts were made to mobilize the entire citizenry to clean up their own premises as well as to put all the garbage and waste at the roadside. The project also sought to stimulate people to clean up the roadsides. The effect was repeated in the next two years but not with the success of the first year in which political supporters of even opposition parties responded in the mutual effort. This year 1990 the project was led by the state company, Solid Waste Management Company.

A separate ministry has now been set up, The Ministry of the Environment and National Service. Plans are now afoot to create an Environmental Authority (a Bill has already been drafted entitled, "An Act to provide for the National Environmental Authority, for preparation of the National Environmental Policy for the conservation, preservation, protection, enhancement and management of the Environment and for matters incidental thereto". The National Environmental Policy is being prepared. In the mean while the work of the clean up campaign has moved to a tree planting effort.

The Ministry of Environment and National Service, consistent with what it defines as a government agreed policy, has spearheaded a group whose task is to examine the problems involved in initiating a clean up of the major rivers and water ways during 1990. The committee brings together persons representing several different ministries, professional bodies, local authorities and the University. This is where we are at.

It should be pointed out that the question of environmental pollution and the protection of the environment has been taken up by several local associations. The Ministry of the Environment and National Service has held Workshop/Seminars on, inter alia,

National Consultations on Natural Resource Conservation and Development 21st February 1990

The Institute of Marine Affairs held a seminar on Environmental Impact Assessment: "Approaches to Socio-Economic Impact Assessment "December 12, 1989".

Today the debate on the environment is being advanced by:

(i)Ministry of the Environment and National Service
(ii)Ministry of Planning and Mobilization
(iii)Institute of Marine Affairs.

One can say that the issue is gathering momentum. The question we must ask is what is the immediate task.

Environmental Pollution and the Ethical Question

We must begin by admitting that the Caribbean Basin states are all vulnerable to growing environmental pollution due to new industries. Their economic conditions can be easily described as desperate. Efforts to rejuvinate their economies from within have not met with much success. While efforts are being made to secure foreign loans, it is being advanced that foreign direct investment(FDI) is likely to be the most fruitful route. The question therefore is how do we ensure that the industries which are in the offering are not those in flight due to stringent legislation in their previous base of operation. The reality of the situation is that most technology transfer agreements are contracts of adhesion, contracts between unequal parties. Invitations to Direct Foreign Investment must be seen more or less in the same light. Often the "beggars cannot be choosers".

The developing countries must rely upon the integrity of the donor and upon the surveillance of the investment agencies and what ever bilateral fraternal relations they may be able to draw upon from other developed countries. The frightening point to note is that the recipient of the D.F.I does not have resident in the country the technical competence to evaluate the full extent of the risk that may be involved. They must rely totally on a moral and ethical code relating to industrial pollution and environmental degradation. While some western European countries have proposed such a code, and while bilateral agreements between countries may have been worked out on such code pervades the industrial market place. In the United Nations family of Organizations (UNIDO, WHO, UNEP, etc.), guidelines have began to emerge on transboundry movement of toxic and hazardous waste. We can only hope that an industrial code of ethics for multi-nationals will be soon in coming. One would also hope that the World Bank and the I.M.F. as well as the other funding agencies will pay more attention to those aspects of the constitutions of aid and loan. But a code of ethics alone will not be able to protect the non-developing countries. What exactly should constitute the code of ethics is yet another question but in essence it should be in international agreement indicating what should be done and what should not be done.

The lead role must come from the United Nations Agencies working in the area, the international Academies of Science, the Environmental Agencies of the developed countries e.g. USEPA and the international professional engineering bodies. They can assist developing countries in selecting clean technologies, in monitoring existing technologies and in cleaning up after technologies and industrial processes have been installed which do not constitute clean technology.

Summary

While the paper presented the basis of the crisis between Industrialization and Development on the one hand and Environmental Degradation and Pollution on the other, the central inevitability of the march of industry is not being negated or resisted. The central message must be that the developing countries must have technical assistance in recycling technologies, clean up and disposal technologies. They must set out to acquire clean technologies. This must govern all technical aid agreements and must underlie all discussion on transfer of technology.

The next important question is that the case for an Environmental Policy cannot be overstated. This must be a vital hard core element in any industrialization policy. The Environmental Policy must identify and treat with the principal elements:

(i) Administration and organizational structure
(ii) Monitoring and inspection
(iii) Legislation and regulations
(iv) Enforcement and sanctions
(v) Avoidance and protection
(vi) Clean up and restoration
(vii) Education and mobilization

Technology is not inherently bad. Technology must be used in the service of man and not recklessly, oblivious of the negative impact on them and the environment.

Under-developed countries can benefit a great deal from the development of a code of ethics for industrial contracts and Technology Transfer agreements. This can form part of the technical assistance package between the developed and the under-developed or non-developed countries.

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AN INNOVATIVE GRADUATE THESIS:
A TEAM EVALUATION OF USED OIL END USES

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In 1989, a team of graduate students specializing in Hazardous Materials Management at Tufts University evaluated the potential health and environmental risks associated with re-use, recycling, and disposal alternatives for used automotive oil. Research into used oil management practices produced a list of currently employed end uses which was narrowed to 14 based on process similarities and potential releases. A qualitative human health risk assessment identified 14 contaminants of concern, evaluated the potential effects of each practice for each contaminant of concern, and resulted in a ranking of end uses according to their relative potential for posing risks. A qualitative environmental assessment was also conducted.

This "Capstone" project concluded a multi-disciplinary Master of Science degree program which included course work in environmental policy, science, and engineering. The study required broad use of these varied technical abilities, as well as management and interpersonal skills. Successful completion of the project required us to recognize and use these non-technical skills. By working as a "consultant-like" project team, we were required to establish a scope of work, schedule, budgets, review process, and report format which met the needs of the client - the Massachusetts Department of Environmental Protection. As with any project, resource and time constraints added to the learning process. These indirect lessons provided the students and advising professors with a learning tool which proved far more valuable than a typical graduate research thesis.

INTRODUCTION

This paper discusses the educational value of a unique graduate thesis conducted under the Hazardous Materials Management Program at Tufts University. The paper presents an introduction to the multidisciplined graduate program and a description of the technical scope of the project which was entitled "Used Motor Oil in Massachusetts: A Prioritization of End Uses Based on Human Health and Environmental Risk." The discussion of the project's initiation and execution includes highlights of how the group organized; developed the project's scope, schedule, and budget; and assigned tasks. The paper concludes with students' reflections on the applicability and relevance of the educational experience to their present positions as environmental professionals.

THE HAZARDOUS MATERIALS MANAGEMENT PROGRAM

This project concluded the first year of the Master of Science program in Hazardous Materials Management at Tufts University in Medford, Massachusetts. The program was developed to meet the growing need for trained professionals in the multidisciplined field of environmental management by providing for the study of interrelated environmental health, science, technology, management, and policy issues. In tribute to this variety, the program was established with three specialty tracks: Management and Policy, Treatment and Clean-up Technology, and Hazardous Materials and Public Health.

The degree program requires all students to complete four core courses regardless of specialization: Hazardous Materials, Fate and Transport of Environmental Contaminants, Health Effects and Risk Assessment, and Hazardous Materials Management Strategies. These courses provide students with the fundamentals of the field. In addition, students choose specific courses in one of the three tracks over two semesters and during a summer institute of condensed courses. Throughout the year, students are required to attend bi-weekly forums offering opportunities to meet with practicing professionals and to examine issues that tie classroom studies with state-of-the-art technology as it is applied by those working in the field.

The multidisciplinary nature of the Hazardous Materials Program was reflected by the diversity of students who completed the program the first year and participated in the project. Our eight-person team ranged in age over 12 years, and in work experience from essentially zero to over 10 years working for industry or in consulting positions. Some entered the program with the intent of changing career directions from traditional engineering to environmental fields, while others wanted to broaden their formal education in their current field of employment. One student wanted to strengthen her technical background before pursuing a career in environmental law. Undergraduate degrees included political science, environmental science, soil science, wildlife biology, and ocean engineering.

The "Capstone" is the final degree requirement of this program. It was defined in course descriptions as requiring students to work in "consultant-like" teams with government officials and industry representatives to address a current environmental issue. Rather than a traditional thesis, the program's developers envisioned a student team, working on a project for a client outside of the academic community, with "real world" deadlines and resource constraints. In addition, the project was to encompass all the disciplines studied during the previous academic year.

PROJECT INITIATION AND DEVELOPMENT

As described previously, the Capstone project is assigned by a "client" and implemented by a "consultant-like" team of graduate students. The 1989 Capstone was commissioned by the Massachusetts Department of Environmental Protection (DEP) to determine the most favorable end uses for used motor oil based on human health and environmental risk. The need for this study evolved from the recent increase in enforcement of the State's "mandatory used oil take-back law." DEP anticipated that more oil would enter the management system, and was seeking to recommend the most environmentally sound end uses for this material.

With little more direction than the project goal stated above, the team set out to develop a scope of work, budget (for expenses other than direct labor), and schedule. The project team had a total of three months to complete the study. During this time the team needed to organize themselves, plan a scope of work and a milestone schedule, research the topic and evaluate data, and produce a final report; all while fulfilling other class requirements and job responsibilities.

To assist the group in organizing the project, the team attended a class in group dynamics led by a professional consultant. Through this exercise they learned about each others' expectations, fears, desires, and needs as they related to working in a group. In retrospect, understanding each team members' strengths and weaknesses helped reduce the number of personality conflicts that are normal in any intense group situation.

To give all students the opportunity to run meetings, the group chose to have a "rotating leadership position" rather than a designated group leader. We scheduled weekly meetings with the academic advisors. This provided a regular opportunity to communicate with all project team members. During the rest of the week individuals or small groups worked independently on specific tasks. This organization was necessary to meet the needs of students' part- and full-time work schedules, travel needs (two students had commutes of over two hours), and family commitments.

The rotating leader's role was to schedule meetings, set agendas, ensure that notes were taken and distributed, facilitate discussion from all group members, and maintain the focus of the meeting. The rotating leadership concept produced several negative situations. Stronger personalities and more experienced team members naturally fell into leadership roles over the course of the project, creating some difficulty because they were not elected or officially designated. On the other hand, lack of this evolution would have hurt the project because the group was easily distracted and fragmented if not reminded of the ultimate goal.

PROJECT EXECUTION

The primary tasks of the project involved research and data evaluation, application of data to a qualitative assessment of risks, and preparation of written and oral reports. Successful completion of each task required assignment of responsibilities to individuals or small groups, establishing schedules, and coordinating work between the individuals or groups. As each phase of the project neared completion, more detailed organization and coordination was needed to bring the project together.

BACKGROUND

The first phase of the project involved intensive research into general aspects of used oil generation and management. This task was accomplished through phone and mail inquiries to industries and regulatory agencies, site visits to interview companies operating in the used oil management industry, and a computerized literature search.

This research revealed that approximately 20 million gallons of used oil are generated annually in Massachusetts. Unlike most other states, Massachusetts regulates used oil as a hazardous waste. This stringent regulatory framework imposes several requirements on generators, transporters, and disposal facilities. Under the Used Oil Retention Act, retailers of motor oil are required to accept up to two gallons of used oil per day per person with proof of purchase. If strictly enforced, this law would provide a network of collection centers and greatly increase the amount of used oil entering the management system. DEP seeks to promote a safe end use for oil in the system by recommending alternatives which pose the least risk to human health and environment.

END USE ALTERNATIVES

Through this research the team collected information from which they assembled a long list of nationally and internationally practiced end use alternatives. The list was categorized to reflect the most commonly employed end uses, and to group those with similar processes and potentials to release contaminants into the environment. Fourteen distinct end uses (Table 1) were identified and classified into four categories. Continued research during the course of the project and input from industries involved in these practices provided a basis for continually revising the list and classifications.

In the interest of efficiency, the team divided into four groups of two to research end uses by category. Individuals chose areas to research based on their backgrounds and interests. Research focused on aspects of the end use which result in potential releases such as air emissions, waste generation, and disposal.

QUALITATIVE RISK ASSESSMENT

The next task was to evaluate the potential risks posed by each end use. Because there are many accepted methods of evaluating risks, the team enlisted assistance from a risk assessment professional and adjunct Tufts professor. Her recommendations helped guide us away from conducting a quantitative risk assessment and instead steered us towards a more appropriate approach, given our time and resource constraints, a qualitative risk assessment. This assistance also enabled us to develop a framework from which to conduct such an analysis.

Research showed that used oil composition is varied and the possible constituents are numerous. In accordance with accepted risk assessment procedures, the team decided to narrow the list by identifying target contaminants of concern (COCs). Chemical and physical property and toxicity data were gathered by dividing the COCs among the team. During a meeting of all group members this data was reported on large tables, and COC selection was conducted by group consensus. The COCs were chosen by grouping chemicals with similar properties; comparing property, toxicity, and concentration data; and choosing the one(s) most likely to have adverse health effects. For example, among the benzene/toluene/xylene group of gasoline hydrocarbons, benzene was chosen as the representative COC because of its higher volatility and carcinogenicity.

With COCs selected, the four groups previously established to research end uses began to evaluate potential releases of the COCs and exposure pathways. Individual matrices were developed for rating the potential risks using a numerical scale. The ultimate fate of the COCs and the potential for transport through air, water, and soil were the primary bases for assigning risk ratings. Qualitative judgements were made by balancing the severity of effects for exposure, availability/mobility in the environment, and concentration in used oil. The team agreed that end uses with multiple source releases (e.g., incineration produces air emissions and ash by-products) all potential releases were considered in the rating.

During this process the students drew from their varied backgrounds and previous year of course work. Process and chemical engineering and waste treatment knowledge was required to understand the reprocessing and re-refining technologies and burning systems. Chemical fate and transport concepts were used to evaluate the persistence and

TABLE 1. USED OIL END USE ALTERNATIVES

Classification/Alternative	Relative Risk Ranking
RE-REFINING AND REPROCESSING TECHNOLOGIES	
• Acid/Clay Re-refining	10
• Vacuum Distillation with Hydrotreating	8
• Chemical Treatment/Demetallization/Clay Polishing	7
• Vacuum Distillation with Clay Polishing	8
BURNING WITH CONTROLLED EMISSIONS	
• Incineration (hazardous waste and municipal)	1
• Asphalt Batching Plants and Cement Kilns	4
• Large Utility Boilers	3
BURNING WITH UNCONTROLLED EMISSIONS	
• Space Heaters (vaporizing and atomizing)	12/14
• Small Residential Boilers	13
• Industrial Boilers (without emission controls)	6
OTHER END USES	
• Landfilling	2
• Landfarming	5
• Disposal in Storm and Sanitary Sewers	9
• Uncontrolled Dumping and Road Oiling	11

of COCs in air, water, and soils. This understanding was particularly important to evaluating the availability of COCs for exposure. Principles learned during our Health Effects and Risk Assessment course were relied on to understand toxicity data and possible exposure pathways. (Similarly, many of these same studies were required to sort out the data when selecting the COCs.)

Our initial approach was based strictly on human health risks. Several team members with ecological and biological backgrounds convinced the group that environmental risk is a critical factor in determining the overall risks of end uses, thereby protecting public health, welfare, and the environment. These students formed a small sub-group later on in the project to address this issue and research methods for conducting an environmental assessment and the potential effects of COCs on a hypothetical ecosystem. The extremely complex interrelationships of ecological systems, the difficulty in defining these systems, and the difficulty of predicting contaminant concentrations in the environment prevented completion of an ecological assessment for all identified end uses.

However, the results of the general assessment were used to support the overall ranking of end uses.

END USE RANKING AND IMPLEMENTATION

During three days of group meetings the small groups which had researched end use categories brought their initial risk ratings to the team for discussion and consensus. A comprehensive risk rating table was developed to sum the risk ratings for each end use from each exposure route. This rating was used to compare end uses and rate relative risk potentials. Alternative end uses with lower numbers represented the least potential for adverse effects on human health. The relative ranking of end use alternatives is indicated on Table 1.

Although simple to describe on paper, the relative ranking process was in fact more difficult than originally imagined. Whereas in other segments of the project different backgrounds helped to facilitate the decision-making process, the diversity made this particular exercise difficult. It was important that the ratings be consistently applied, however the rationale for each rating was often changed the next time a similar circumstance arose. New information from later ratings required changes to end uses rated early on, and there were many opinions about how risk ratings should be assigned. This made it very difficult to reach consensus and proceed to the next phase of work. Nonetheless, progress was made and the end uses were rank ordered as shown on Table 1.

REPORT PREPARATION

Our primary goal of end use ranking accomplished, the group again divided responsibilities according to personal talents and interests to get the job done. Some students took on the task of typing, editing and generally producing what was to become a 150-page report. Writing styles varied greatly, and one person accepted the task of overall editor. Another student, with a demanding work schedule which often precluded him from working with other group members, took on the task of producing the graphics for the report, a job which could be performed on an independent schedule. One person accepted the tedious task of assembling and listing the over 100 references used in the project and checking reference notations in the text for consistency and accuracy. Other students researched the feasibility of implementing the preferred alternatives by contacting industry representatives and regulatory officials.

RESULTS

Implementation of three of the preferred end uses (hazardous waste incineration, landfarming, and landfilling) was judged to be inapplicable in Massachusetts due to regulatory restrictions, capacity limitations, and/or public opposition. The feasibility of utility boilers, asphalt batching plants, and municipal incinerators was further evaluated based on economic and practical advantages and disadvantages of recycling used oil in these respective capacities. Utilities and asphalt batching plants are willing to accept and consume used oil as a fuel supplement. They have abundant oil burning capacities and realize lucrative economic incentives by burning a less expensive fuel. It was agreed, however, that cumbersome permitting procedures and a need for high quality assurance programs for the incoming fuel are the main disadvantages of these end uses.

In addition, the group proposed that although municipal incinerators may be a feasible option, more information is needed to make a final determination. The disadvantages of municipal waste incinerators were found to be (1) inadequate capacity when used solely as a start-up and shut-down fuel; (2) unwillingness of the industry to accept the oil without a fee; and (3) possible negative public reaction to burning a classified Hazardous Waste in the Commonwealth of Massachusetts.

Although not strictly part of our scope, the group's enthusiasm generated three specific recommendations for improving the management of used oil.

1. Establish a more efficient permitting process to expedite decisions on pending applications for utility boilers and asphalt batching plants.

2. Initiate further studies on the feasibility of using used oil as an auxiliary fuel in municipal incinerators.

3. Institute a source reduction program to decrease the amount and upgrade the quality of used oil entering the management system.

Another task not strictly included in our scope was consideration of source control/waste minimization strategies. Several team members with particular interests in this area researched this issue. Suggested methods of source reduction for motor oil include the use of water soluble oils, substitution of oils, extending the useful life of oil products, reformulation, use of biodegradable oils, and employee training programs aimed at waste minimization.

CONCLUSION: BENEFITS AND DRAWBACKS OF A GROUP THESIS

As described previously, this project differed from a typical graduate thesis in many ways. First, it was a group project rather than an individual effort. This factor allowed the team to perform a tremendous amount of work in a short time, but required more organization and communication, and compelled eight individuals to work together. Pursuit of individual interests gave way to combining efforts on the client's desired objective to meet the established schedule and budget.

Similar to the execution of a project under a typical matrix company organization, the wide diversity of team member backgrounds and interests presented difficulties and benefits during the life of the project, enabling the group to more completely address the issue of used motor oil. On one hand, this individual variation provided the team with specific talents to contribute to the project. While editing, typing, graphics and proofreading skills were necessary to complete the project, some students were more proficient at research, others at writing. In addition, this project required knowledge of engineering, chemistry, biology, environmental fate and transport, toxicology, environmental law, and public policy. The team's diversity provided the needed capabilities in each of these areas, which allowed for the most efficient use of resources for successful completion of the project. Like a real consulting team, each member did his or her part to contribute to the success of the whole. In contrast, this diversity sometimes made it more difficult to keep the group focused on the scope of work and agree on the approach.

While some thesis research is supported by grants from interested parties, not unlike "clients", this project was performed to meet specific short term goals of the Massachusetts DEP. This meant that the final product, the report, needed to support recommended alternatives for the re-use or recycling of used oil. The final product of eight individual's efforts needed to be formatted into one report, without style or format changes, repetitions, or omissions.

After completion of the project we looked back at the program and thought about what the experience had meant to us. The benefits varied according to the background of each person. Those in the group with experience in the environmental field enhanced their professional development, sharpening their interpersonal and management skills and learning to interrelate different fields.

Probably the most important benefit of this project was the emphasis of the "process" of project execution and development of interpersonal skills. How we relate to others on a project team and to our clients, what skills and interests are most valuable to a group effort, how we communicate with others, and how we react under pressure were all lessons that would not have been learned in a traditional thesis.

Overall, a group thesis is recommended as a valuable method of providing students with hands-on academic training coupled with professional development. Producing a document that serves the needs of a real client increased our motivation and attention to quality throughout the project. Since completing the project in August 1989, we believe that the "Capstone" was invaluable in preparing us for working in consulting or regulatory organizations. The students agreed that no exam nor individual project could have given them the educational experience that came out of this unique graduate thesis.

Presentation at the Opening Plenary Session of the

INTERNATIONAL CONFERENCE ON POLLUTION PREVENTION: CLEAN TECHNOLOGIES AND CLEAN PRODUCTS

by: Dr. A. Tcheknavorian-Asenbauer
Director
Industrial Operations Technology Division
United Nations Industrial
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Mr. Chairman, Honorable Guests, Distinguished participants from governments, non-governmental organizations, and the private public.

It is a pleasure for me, today, to address this Conference, on behalf of the General Director of UNIDO, Mr. D.L. Siazon, and to thank the Conference organizers, the U.S. Environmental Protection Agency, and the International Association for Clean Technology, for inviting UNIDO to take part in this important Conference.

The fact that we have gathered here today is partly due to the historical and current international mission of this city. Washington, as a center for many international organizations, allows a cross-fertilization of ideas, politics and expertise, and important contributions to the problems with which the international community is confronted. I trust this Conference will be marked by the determination to go ahead and achieve tangible results in an area which is a truly vital one for all mankind.

The internationally well-known Brundtland Report, "Our Common Future," and other timely reports from national and international organizations concluded that intensification and broadening of environmental policy are urgently needed. However, we are realizing that achieving a higher environmental quality will be a process that will last several decades. We need the exchange of technical know-how and strategic approaches at national, regional, and international levels in order to ensure that we reach our common objective of sustainable development.

Acid rain, depletion of the ozone layer, global warming, hazardous wastes, pollution of coastal and inland waters, are all supranational or even global issues, impinging on the health and survival of humanity. They cannot be solved in isolation. Work at the national level has to be linked with work at the interregional and international levels. International conferences and international agreements are highly desirable, promoting global awareness and exerting moral persuasion on national governments and industry.

In light of international awareness, the United Nations Industrial Development Organization (UNIDO), which has been mandated to give developing countries technical assistance in the field of industry, is working seriously in integrating environmental management in all aspects of transfer and application of industrial technologies. Without such environmental management, no sustainable development will be possible in an already endangered world. While it is true that the complexity of environmental problems, the technological feasibility, and the financial implications of solutions are different from country to country, and particularly between developing and industrial countries, we will still find ourselves in the same boat, or to put it more adequately for our modern times, in the same spaceship. We cannot opt out of that system.

We, in UNIDO, interpret "environmental management" as the prevention and/or abatement of undesired effects of industrial activities with emphasis on promoting a preventive approach through clean technologies. Our thinking reflects current international awareness in an effort to reverse the environmental degradation.

At the operational level, a wide spectrum of industrial experts in agro-industry, engineering, metallurgy and the chemical industries, as well as in feasibility studies, management, planning, institutional infrastructure and human resource development, are taking part in the implementation of different activities in the field of the environment through the provision of expert services, supply of required equipment and arrangement of training. In 1988, UNIDO had 51 technical cooperation projects under implementation that dealt entirely or in part with the environmental aspects of industrial development. By early 1989, UNIDO had developed over 80 new project proposals in the field of environment totaling US$44 million. These projects cover air and water pollution control, solid waste control, waste utilization, hazardous-waste management, and various aspects of industrial safety and emergency contingency planning. An Environmental Coordinating Unit is being established to ensure integration of environmental considerations into all UNIDO projects. We hope that this forum will give us the opportunity to find partners to cooperate in the implementation of the above mentioned projects.

The challenge before UNIDO and other international organizations is to help developing countries to develop these policies and strategies that will promote not only remedial solutions to environmental problems, but solutions, technological solutions, that will reduce industrial waste generation and will be more conducive to sustainable development. From UNIDO's experience in promoting industrial development, these solutions will not come about unless international organizations respond to two issues.

First, developing countries must be assisted in acquiring the know-how and awareness that enable them to identify, assess and adapt technologies and management practices that will safeguard the sustainability of their natural and human resources. They must be persuaded, by implementing specific projects, that pollution prevention pays. They need to see that the introduction of clean technology can reduce costs and at the same time reduce harmful pollutant discharge to the environment. These projects must demonstrate that the benefits of clean technology, reduced production costs, and mitigation of harmful effects on human health and the environment, can exceed the costs of the new investments. A list of projects will be available at the Conference.

Second, the industrial countries through bilateral and multilateral efforts make additional development resources available to implement this approach quickly and fully. "Additionally," no conditionality of resources, is a necessary ingredient to implementing solutions. Developing countries want to improve their standard of living in general, but if resources are limited, the choice is difficult to make. Financial constraints have been, therefore, a major bottleneck in expanding the integration of environmental resources management as widely and as rapidly as would be desirable.

Nevertheless, noticeable progress has been achieved in developing countries. An increasing number of decision-makers are actively pursuing external assistance in strengthening their know-how and measure in both remedial and preventive programmes for the minimization of the deterioration of water, air, and land resources. The need to reduce waste and especially, hazardous wastes, is perceived as one of the priorities among many developing countries.

Clearly, we in the multilateral organizations stand to benefit from the work of governmental and non-governmental organizations, such as the co-hosts of this important conference: the U.S. Environmental Protection Agency, and the International Association for Clean Technology. Increasing awareness of the potential of clean technology is clearly necessary if developing countries are to appreciate its benefits. I would like, in this stage, to mention that the cordial and useful cooperation that UNIDO has with UNEP and other UN organizations such as UNDP, The World Bank, and WHO.

We, in UNIDO, are particularly pleased that the formation of the International Association for Clean Technology took place during one of our public awareness events, the International Expert Workshop on Hazardous Waste Management, which took place in Vienna in June 1987. We share with pride the good work of the Association.

During this Conference, there will be ample opportunity to exchange expertise in policies, strategic approaches, and technologies promoting pollution prevention and clean technologies. The combination of economic, technical, and industrial interests with environmental management is a great challenge for the future. This Conference can play an important role in the ongoing international debate about the relevance of clean technology for achieving sustainable development in developing countries.

For the next three days, you have indeed a challenging task, and I am wishing you a fruitful, successful Conference!

CLEAN PRODUCTION: FROM CONCEPT TO INTERNATIONAL CAMPAIGN THROUGH NETWORKING

Beverley Thorpe
Lisa J. Bunin

Clean Production campaign
Greenpeace International

Networking is the lifeblood of Greenpeace. It is the key to our success as an organization. We build "networks" for circulating and soliciting ideas, philosophies and positions in order to influence and initiate activities to protect the future of the ecosphere. Our network consists of the public, politicians, professionals and other public interest groups who have a common interest in halting human activities which adversely affect the environment.

Action and information campaigns provide the springboard for getting our message out to the public, and in turn, broadening our global network of contacts and supporters. Such campaigns further serve to raise key issues of environmental concern onto the international political agenda, for examination and discussion by the media, and to facilitate increased awareness and involvement by the public.

"Reduce It, Don't Produce It," and "Clean Production" are the banner headlines used to support Greenpeace's campaign against toxic pollution. These simple yet effective phrases convey the message that the only way to truly solve the toxic waste crisis is to eliminate the source of the problem--toxic products and waste. Through active campaigning by Greenpeace and others, this concept has been increasingly adopted and promoted by people throughout the world as the only realistic way out of the pollution crisis.

Yet the implementation of these concepts in national and international political fora is only beginning. And here's the crux of the problem. This paper discusses two different approaches to promoting the adoption of Clean Production strategies and activities by government and industry.

Part one examines a waste disposal campaign and examines how "networking" on the issue of Clean Production led to a ban on incineration at sea. It shows how public opposition was a crucial element in leading to a political decision to ban this practice and it also shows how waste disposal technology is a major disincentive to waste reduction.

Part two examines Greenpeace's campaign to expose and propose remedies for the current lack of an integrated Clean Production strategy by North Sea states. It is concluded that the promotion of Clean Production will entail a switch to the focus on the product itself that will entail a complete reassessment of production and ultimate phase-out of harmful processes and products. To achieve this will involve a new societal involvement and closer networking by policy-makers, industry and the public.

NETWORKING AND THE PHASE OUT OF OCEAN INCINERATION

The US Experience

Greenpeace launched its campaign against incineration at sea in 1982, when it became clear that the United States government wanted to import the European technology to provide a panacea for the country's growing waste crisis. At the same time in Europe, there was growing concern that the technology, intended as an interim step in the phase-out of ocean dumping, was emitting dioxins in the North Sea.

The aim of Greenpeace's campaign against ocean incineration is threefold:

1) to stop the use of the world's oceans for dumping industrial, chemical waste;

2) to target toxic waste generation as the source of the waste crisis and its elimination as the only solution;

3) to block the spread of another polluting disposal technology which results in the perpetuation and legitimization of wasteful and harmful industrial practices.

In the United States, the Greenpeace campaign began to network and share information with communities along the proposed waste transport route to the waste storage facility in Emelle, Alabama. This was done in preparation for a public hearing on the proposed issuance of a permit to burn PCB-contaminated waste in the Gulf of Mexico. More than 6,000 people attended the first public hearing on the issue, in Texas in 1983.

An anti-ocean incineration network emerged in coastal communities in anticipation of future proposals, with Greenpeace informally designated as the national coordinating body. Included in the coalition were Congressional, state and local officials of the potentially impacted states. Due to intensive public protest, in 1984, the Gulf proposal was withdrawn as was a subsequent proposal, in 1986, to burn PCBs in the North Atlantic off the East Coast. No burn has taken place in the U.S. since 1982, due to a strong network of people who lacked confidence in the proposed ocean incineration programme.

The European Experience

The end to ocean incineration in the US, provided the necessary fuel to fire the campaign in Europe. In 1985, 1986 and 1987 (1,2,3) Greenpeace published several critiques on ocean incineration. Each report highlighted the fact that ocean incineration discouraged the development of waste reduction technologies and that its availability perpetuated waste generation.

One report noted that "safer methods involving process modifications to reduce hazardous waste generation are simply not attractive to industry if it can send its by-products to the lowest bidder, instead of fronting capital for process improvements."(4) The issue of liability was also key. Another submission pointed out that ocean incineration allowed industry to escape responsibility for its hazardous waste generation because the resultant environmental damage could never be linked to the original waste generator.(5)

This information was circulated to decision-makers in all North Sea governments to draw their attention to scientific and technical flaws associated with the technology and its supporting theories. Several Greenpeace actions aimed at forcing incinerator ships back to port served to expand the organization's supporters and network. Soon thereafter the National Union of Seamen in the UK and the National Federation of Fishers, in Denmark, launched campaigns to end ocean incineration. Local communities in England and the Netherlands also successfully defeated proposed expansions of port storge facilities for hazardous waste destined for ocean incineration. A new European network was born.

Influenced by growing public opposition and extensive media coverage of the burn ship operations, the Second International Conference on the Protection of the North Sea agreed to end ocean incineration by 1995 with a 65% reduction of wastes burned by 1991. (6)

After the Ban: What Solutions?

What would industries and national governments do to comply with this decision? Caught off guard by the rapid phase-out, the Commission of the European Community (EC) organized a seminar on "The Management of Liquid Organo-halogenated Wastes after the Prohibition of Incineration at Sea." (7) A paper presented to the conference by the Institute for European Environmental Policy pointed out several waste reduction techniques currently available for waste streams sent to ocean incineration. (8) Specifically, a 15% decline in applications from chlorinated solvent users in the Federal Republic of Germany was expected to continue. This was due to a new waste management policy to recycle, reuse or eliminate waste formerly sent to ocean incinerators. (9)

The paper further reported that glycerin and polyurethane could be produced in a chlorine-free process. Regarding pesticide and pharmaceutical production, it was noted that "these industries are rather innovative and will react themselves if the incentives to miminimize their waste production are sufficient." Of equal importance, was the realization that some actual products, such as PVC, were more of a problem than their resultant waste streams.

Although process and product substitutions were clearly available, industry and governments resisted embarking upon a full-fledged waste reduction initiative. Land-based incineration was still the favoured policy alternative despite the recognition by delegates to the EC seminar that "immediate substitution of sea incineration by incineration on land faced problems of public acceptance and licensing."

As a means of refocussing the debate back on waste prevention, Greenpeace compiled a "Clean Technology/Source Reduction Contact and Reference list to Facilitate the Phase-out of Ocean Incineration." (10) This document, submitted to the London Dumping Convention, shows that waste prevention is a feasible and realistic option by identifying contacts and source materials on the regulatory, technical and management aspects of Clean Production. The document has since been published as an information booklet and widely distributed, to international policy makers, industrialists, environmental groups and the public.

The North Sea Ban

With heightened public resistence to ocean incineration and growing concern for the health of the North Sea it became increasingly difficult for industry to use this waste disposal option, despite a future end date being agreed. In Germany, the largest contributor of wastes, large scale opposition to a proposed new port storage facility in Emden put pressure on the government to end the practice sooner. The subsequent disclosure that waste containing dioxins remained in storage awaiting incineration at sea, led to the abrupt end to the use of ocean incineration by that country in 1990.

This heightened public concern and subsequent lack of commercial confidence in the technology led to an earlier termination date by other North Sea states. All remaining user countries agreed to terminate ocean incineration by the close of 1991, at the Third International Conference on the North Sea held in March, 1990. (11) However, although an agreement was finally reached to phase-out ocean incineration, the question still remains as to what will actually be substituted in its place.

Submissions by various North Sea states to the London Dumping Convention reveal a preference for future land-based incineration and disposal technologies (12) although full access to information on European industrial waste generation is incomplete due to confidentiality and insufficient data. This raises the issue that no guidelines were given on the implementation of the phase-out of ocean incineration. Neither was there a policy focus to ensure that public and political concern would not again occur over the proposed solution to ocean incineration.

THE NORTH SEA - TIME FOR CLEAN PRODUCTION:
The Need for Implementation

The North Sea is a priority campaign area for Greenpeace because it is the most heavily industrialized sea in the world and is the direct recipient of most of Europe's waste streams. The eight countries who border the North Sea are the UK, France, Belgium, the Netherlands, the Federal Republic of Germany, Norway, Sweden and Denmark.

The Ocean incineration Campaign is only one of many Greenpeace campaigns calling for a halt to the generation of hazardous waste and products: the North Sea campaign exposes all the polluting discharges into the sea while calling for the implementation of waste reduction programmes. As has been Greenpeace's experience with ocean incineration, agreements to reduce the totality of toxic inputs into the North Sea lack guidance on how this can be achieved.

The Second International Conference on the Protection of the North Sea in 1987 agreed to "accept the principle of safeguarding the marine ecosystem of the North Sea by reducing polluting emissions of substances that are persistent, toxic and liable to bioaccumulate AT SOURCE, by the use of the best available technology and other appropriate measures." Thus goals and timelines were set to reduce "dangerous substances" by 50% by 1995, while ocean dumping of wastes would end by 1989.

However, a series of reports by Greenpeace analyzed North Sea national policies and found great discrepancies. There was no consensus over what constituted a "dangerous substance" and for the most part no background data was available to properly assess the success of a percentage reduction to pollution loads. (13)

Furthermore, in direct contradiction to preventing pollution "at source" all national policies to control pollution entering the North Sea have been based on the use of 'Best Available Technology.'(BAT). For the most part BAT is defined as "end of pipe" solutions with the added proviso that economic considerations define what is considered the "best" that is available. (14)

Extensive national lobbying using these analyses ensued whilst Greenpeace actions against direct discharges of waste into the North Sea publicized the theme of Clean Production and '0-2000' -- the complete reduction of toxic wastes into the North Sea by the year 2000.

The New Environmental Paradigm

As well as critiquing the national implementation plans of the North Sea states, Greenpeace commissioned a report from a Dutch university to outline the necessary steps the eight North Sea would need to implement a Clean Production programme and achieve zero discharge of toxic wastes. This report, Protection of the North Sea: Time for Clean Production, was sent to all European Environment Ministers and networked extensively to the public to force the adoption of this new environmental paradigm for future policies. The report introduced the concept of Clean Production to many legislators for the first time. (15)

As a first priority the report details how Clean Production is the antithesis to "end of pipe" pollution controls. Clean Production is defined as industrial systems which avoid, or eliminate hazardous waste and hazardous products, and use a minimal amount of raw materials, water and energy. Furthermore goods manufactured in a Clean Production process must not damage natural ecosystems throughout their entire life cycle. Clean Production, therefore, demands a conceptual and procedural approach to production. It demands a total societal commitment by industry, government and the consumer.

This makes product policy crucial and the following components can be assessed with this in mind:

- the societal relevance of a product

- the design of the product and product-development
- the raw materials used in its production
- the consumption phase
- the products in the disposal phase

Clean Production does not include "end of pipe" pollution controls such as filters and scrubbers or chemical, physical and biological treatment. Measures which purport to reduce the volume of waste by incineration or concentration, mask the hazard by dilution or transfer pollutants from one environmental medium to another are also excluded.

The Current Policy Challenge

To this end the report recommended basic criteria the North Sea states would need to adopt to push the concept of Clean Production into actual policy and practice. These can be briefly summarized:

Industry must do a toxic use audit to fully understand how much toxic waste is generated. Clean Production must then be the first priority option when assessing alternative products and processes.

Governments must use regulations and economic instruments. Two key elements are permitting requirements that mandate clean technologies and strict liability for damages caused by industrial processes. This must be accompanied by full public access to information and participation in the regulatory scheme. Enforcement must be sufficient to deter companies from breaking their permits. Technical assistance must be available as part of the support system.

Consumers must become aware of their role in moving society towards Clean Production. Full information of a product's life cycle is essential. Reduction, reuse and recycling must develop as the new criteria for product acceptability.

Networking for the Future

The level of debate and discussion on Clean Production is rising. Since the Third International Conference on the North Sea there has been a demand by the European Parliament to replace the use of Best Available Technology with Clean Production methodology as the modus operandi for North Sea issues. (16)

However, this new paradigm will demand a new type of networking based on increased awareness of the total societal responsibility for Clean Production. It will demand a radical change in industrial production and consumer behaviour to embody a deeper understanding of the connection between production, consumption and environmental degradation. Whatever form this networking takes, it is assured that public campaigns against environmental damage will transcend issues of waste generation alone and will focus equally on the product itself. Just as ocean incineration resulted in a legislative ban so too must harmful products and processes be phased out. It is Greenpeace's recommendation that those halogens, previously burned at sea, be the first class of chemicals to be banned as products. Market force or mandate? Whatever the economic method, the challenge now is to implement this move toward Clean Production.

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Title: RECOVERY OF CHROMIUM FROM TANNERY WASTEWATERS

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Abstract:

Chromium discharged as effluent in concentrations of 2.000 - 3.500 mg/l, is recovered and recycled back into the tanning process by using a method developed by the Dutch institute TNO: the collected wastewaters are treated with MgO (coagulation - flocculation - sedimentation) and the produced sludge is redisolved in sulfuric acid. This solution is fed back into the tanning drums by standartized technique, thus resulting in savings of "fresh" chromium quantities of up to 30 - 35%.

The removal efficiency is almost complete, producing a clear supernatant with a chromium content of less of 2 mg/l which can be reused for washing and cleaning purposes.

This project is now in progress, being elaborated in a Greek tannery in cooperation of Greek authorities with Dutch counterparts and the EEC.

INTRODUCTION

The tanning production process is practically the transformation of raw animal hides into leather and related products.

The hides are converted into leather (tanning) by means of tanning agents which are either natural organic substances (tannins) or Cr^{3+} - salts. The discharged effluents are some of the most polluting industrial wastes. Their treatment and disposal is therefore vital for the protection of the environment. This problem becomes more critical for countries where most of the plants are either small-size units with small economic background, or where they are located near water bodies and the effluents are discharged without the appropriate treatment.

DESCRITION OF THE PRODUCTION PROCESS - - WASTE SOURCES

The production process can be separated in two parts: preparation of the hides to receive the tanning agents (beam - house processes) and the tanning process itself.

BEAM-HOUSE PROCESSES

1. Washing - Soaking

The hides are first washed to remove dirt and blood, and then soaked for the removal of salt and for softening. The produced wastewaters contain a high organic load (BOD_5) due to the dirt and blood along with a high concentration of salt.

2. Fleshing

The next step is the removal of muscle and fatty tissue adhering to the corium layer by means of revolving knives while a continuous stream of water carries away the produced impurities. The wastewaters from this process contain fat and fleshy particles.

3. Liming

Liming is done to swell the hides for the better penetration of the tanning agents and for the hair removal. The hides are placed in vats containing a lime suspension. Small quantities of sodium sulfide are added for the acceleration of the process. These waters are heavily polluted with high concentrations of sodium sulfide, lime and organic matter.

4. Unhairing - Washing

The unhairing of the hides is accomplished mechanically by means of rolling knives. Large amounts of water are used to flush out loosened hairs and excess lime. The related wastewaters contain fine hair epidermal particles and lime.

5. Deliming - Bating

The hides are washed and then subjected to a process known as bating. During this process some proteins, such as elastin, are hydrolyzed in order to avoid any negative effects on the quality of the final product.

TAN-YARD PROCESSES

After bating, the hides are ready for tanning. Two principal methods of tanning are used according to the related tanning agents: vegetable tanning and chrome tanning.

1. Vegetable tanning

The tanning operation is carried out in vats where the hides are kept in contact with the tanning solutions for several days.

The waste discharge is intermittent and heavily polluted with organic load and colour.

2. Chrome tanning

For the chrome tanning process the bated hides are first soaked in a solution of sulfuric acid and salt, for 10-16 hours. This operation (pickling) helps the better absorption of the chrome salts into the pores and tissues of the skins. After pickling, the hides are kept in contact with the tanning solution containing either salts of Cr^{III} or sodium dichromate which is reduced to Cr^{III} by reducing agents. The effluents contain high concentrations of chromium salts.

Finishing

After tanning a series of operations known as *finishing* processes are carried out to produce different types of leather (oiling, dyeing etc.).

WASTEWATER CHARACTERISTICS

On Table 1, a rough distribution of the quantity and quality of the wastewaters in a chrome tannery is shown as a percentage of the total quantity.

TABLE 1

Process	Volume of wastewater (%)	BOD_5 (%)	S^{--} (%)	Cr^{3+} (%)
Beam-house	90	90	100	-
Tan-yard	5	5	-	99-100
Finishing	5	5	-	0-1

Table 2 shows a similar distribution for a tannery using tannins as tanning agents.

TABLE 2

Process	Volume of wastewater (%)	BOD_5 (%)
Beam-house	90	42
Tan-yard	5	47
Finishing	5	11

Table 3 shows a detailed flow and load distribution within a tannery.

TABLE 3

Qualitative and quantitative data of tannery wastes

Production process	Wastewater Volume, % of the total	BOD_5 (mg/l)	SS (mg/l)	Dissolved solids (mg/l)	Total solids (mg/l)	pH
Washing-Soaking	42	1000-2500	1500	13500	15000	6.6
Liming	16	14000-15000	7000	26000	33000	11.6
Washing	16	650	-	-	-	-
Deliming-Bating	10	4000-6000	100-200	4300	4400-4500	8.2
Pickling	6	3000-4200	1000	10000	11000	2.4
Vegetable tanning	3	5000-20000	1300	17000	18300	5.0
Chrome tanning	5	700-1000	300-2000	5000	5800-7000	3.2
Finishing	5	2000	500	2000	2500	3.9

The main pollutants found in tannery wastewaters are the high concentrations of organic matter, suspended particles and salt. Two other constituents, chromium salts and sulfides demand special attention in order to prevent their negative effect on the environment.

POLLUTION CONTROL TECHNOLOGY

Several treatment methods are generally applied with various efficiency grades.

Tables 4 shows the related figures.

TABLE 4

Treatment Removal Efficiences

	Pollutant reduction efficiency			(%)
	BOD_5	SS	Chromium	Sulfide
Screening	5	5-10	0	0
Sedimentation	25-62	69-96	5-30	5-20
Chemical coagulation	41-70	70-97	50-80	14-50
Trickling filtration	65-80	85-90	25-75	75-100
Activated sludge	85-80	80-95	75	75-100

Preventive measures - Treatment methods. The elementary method mainly used in small tanneries consists of the by-products recovery such as flesh, hair etc. while the use of definite water amounts instead of a stream of water in the beam-house processes (wasning) helps to reduce the produced wastewater volume.

The equalization of the flow followed by sedimentation, helps to remove part of the suspended solids (40 - 50%) and a small fraction of BOD_5 (30%).

Coagulation with lime or iron and aluminium salts is also frequently used with various removal efficiencies. However, the produced amount of sludge creates another serious problem.

The Dutch research institute TNO has developed an alternative solution for the BOD_5 removal without any biological treatment using the fact that 90% of the organic matter comes from the beam-house process and consists mainly of dissolved proteins: After the stream segregation from the tan-yard and the sulfide removal, the pH is requlated to 3.5 - 4.0 by adding hydrochloride or sulphuric acid. This acidification of the wastes helps the flocculation of the dissolved proteins and the production of a floating "cake" which can easily be removed.

Biological treatment is a generally accepted method for tannery effluents concerning their organic load and sulfide content. There are controversial opinions about the chromium removal efficiency achieved by related biological treatment plants claiming that chromium accumulates in the biological sludge in the form of settleable solids thus being withdrawn from the liquid wastes, whereas the opposite assumption is based on the only slight alkaline environment of the biological treatment systems (pH 7.5-8) which prohibits the quantitative precipitation of chromium salts.

Combined treatment of tannery effluents with municipal wastewaters leads to acceptable results when the hydraulic load coming out from the tanneries is kept below 20% of the total quantity to be treated.

In any case the removal of chromium is a necessary step prior to any further treatment.

CHROMIUM RECOVERY

Cr^{III} salts are widely used as tanning agents for the production of durable and stable leather goods, however their discharge over the effluents can cause severe damages to the environment. Therefore strict effluent limitations have been adopted (2-5 mg/l) prior to their discharge either into sewers or directly to water bodies.

An effective and attractive method for the complete removal of chromium constituents is their recovery from the effluents and their recycling in the production (tanning) process.

A related demonstration project is now in progress in a Greek tannery which is being elaborated in close cooperation of Greek and Dutch authorities and institutions and the European Economic Community (EEC), which is covering part of the costs.

The main scopes of this project are the recycling of chromium and the reduction of water consumption in the tannery.

The applied technology is developed by the Dutch institute TNO which is the technical project leader together with the Greek Ministry for Environment, Physical Planning and Public Works.

The technical procedure is based on the following aspects:

The tan-yard effluents (Cr - content: 3200 mg/l) are separated from all other wastewaters and collected in a sedimentation tank where they are treated with magnesium oxide (MgO). All chromium salts are then converted into chromium hydroxide ($Cr(OH)_3$) - sludge which is accumulated on the bottom of the tank. After the discharge of the clear supernatant with Cr-content less than 2 mg/l, this sludge is redisolved in sulfuric acid (H_2SO_4) and the produced solution is fed back into the tanning drums replacing the required "fresh" chromium quantities of up to 35%.

The clear effluent can be used for washing and cleaning purposes whereas a further reduction of water consumption can be achieved by adjusting the tanning receipe to skin washing procedures instead of rinsing.

Technical data

- Daily production : 8 tonnes
- Chromium consumption (as Cr-compounds) : 400 kg/day
- Chromium consumption (as Cr) : 68 kg/day (17 ton/year)
- Chromium quantity in the effluents (to be recycled) : 22.4 kg/day (5.6 ton/year)
- Chromium concentration in the effluents (before treatment) : 3.200 mg/l
- Chromium concentration in the effluents (after treatment) : 2mg/l
- Tanning effluent quantity : 7 m^3/day

Economical data

Installation costs : 7.500.000 Gdrs (50.000 $)

Value of recycled chromium quantity (7.5 $/kg) : 6.340.000 Gdrs (42.000 $)

Operational costs (Chemicals, energy costs, manpower) : 1.500.000 Gdrs (10.000 $)

Net savings : 4.840.000 Gdrs (32.000 $)

Organizational arrangements

The demonstration project which is now being implemented in Greece is a good example of a smooth cooperation between several parties. According to the programme formulation the following organizational scheme has been developed:

Ministry for Environment (Greece) : Project leader responsible for the whole project

Institute TNO (The Netherlands) : Project leader responsible for technical aspects

Hellenic Leather Center (Greece) : Laboratory support - financial arrangements

Ministry for Environment (The Netherlands) : Financial - organizational support

Germanakos tannery (Greece) : Construction - operation of the recycling installation

European Community (EEC) : Financial support

The total budget amounts 24.000.000 Gdrs (160.000 $) covering all aspects of the project: collection of data, technical design, laboratory analysis, construction - operation, transfer of knowledge, travelling.

CONCLUSIONS

This demonstration project combines on a very effective way the requirements of minimized wastewater discharge with economical benefits for the industry, so that the proper functioning and operation of the related facilities is not only a matter of control of the environmental authorities but also closely linked with the industry's economic interest (raw material saving).

In parallel it will help to overcome some misunderstandings which are widely spread concerning pollution control, namely that biological treatment plants are capable for the removal of any chemical substance from wastewaters and that coagulation - flocculation techniques are the only existing alternative solution.

As a matter of principle the reduction of pollution load at the source and the recycling - recovery of valuable materials from the effluents prior to discharge should always be the main concern of managers engineers etc. by tackling industrial pollution problems and only if all possible techno-economical possibilities are exhausted, end - of - pipe - technologies should be applied.

In countries where the POLLUTER-PAYS-PRINCIPLE (PPP) has been widely adopted, the minimization of pollution load discharge into the sewer by using recycling - recovery techniques will cut down the usual fees paid for being connected with the wastewater collection and treatment system. It should be kept in mind that the adoption of environmental taxes is a crucial aspect of equal competition conditions among industrial branches: the industrialized countries are increasingly complaining that industries in developing countries create favourable economic environment for their industries (lower costs) by neglecting to apply strict pollution control regulations. And this happens not because natural resources are abundantly available there, but mainly due to financial difficulties and ignorance of nature's restricted abilities to cope with man's disturbing activities.

Therefore the direction to be followed is clear: waste minimization at the source, recycling of valuable material, economy linked with environmental protection.

WASTE PREVENTION STRATEGIES IN THE FLEMISH REGION OF BELGIUM

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1. INTRODUCTION

In Belgium the coordination and implementation of Waste Management has been delegated to the three regions.

Every 5 years, the Executive Government of the Flemish Region (60 percent of the population, 70 percent of the industry) draws up a Waste Management Plan that has the force of a decree. The second plan, for the period 1991 to 1995, contains items aimed at concretizing an industrial waste minimization program. With the first Flemish Prevention Plan we aim to reach, among other objectives, the following goals:

- Merge the waste planning and the economic planning in order to reach an ecologically sound planning
- Draw up a common hazardous substances inventory of the Flemish industrial production apparatus
- Take stock of the existing technologies for the processing of hazardous substances
- Obtain and assimilate the low and no-waste generating technologies
- Determine the means (financial, juridical, technological)
- Lay down a suitable environmental policy on production and consumption of hazardous materials.

The draft decree on waste management will be submitted for inquiry and scrutiny to the general public and the industry during the months of September and October 1990. The definitive version of the plan will be adopted by the flemish Parliament before January 1, 1991. Once approved, it will have force of decree.

2. WASTE GENERATION IN THE FLEMISH REGION

The trend of the total Flemish waste shown in table 1 is clearly indicative of a substantial increase of the quantity of waste, running somewhat parallel with the general pace of economic development.

Table 1: General view on the waste product in the Flemish region of Belgium.

Waste Type	million ton 1985	million ton 1988
municipal waste	1,6	2,3
industrial waste	3,5(estimated)	5,3(estimated)
bulkwaste	8,2	6,3
dredging spoil	3,0	4,1
wastewater sludge	0,08	0,16
sewage sludge	0,6	0,8
manure surpuls	0,3-3	1,7-3,6
construction waste	2,0	4,6
waste oil	0,15	0,2
hospital waste	0,04	0,06
car wrecks	p.m.	0,11
Total	18-22	24-28

Due to low energy and raw material prices and the almost total lack of incentives aimed at strengthening the market recycled products, reducing disposal by dumping proved nearly impossible during the eighties and recycling remained at its perpetual modest level. The percentage of dumped waste remained at a constant 40 to 41 percent throughout the years 1982 through 1987.

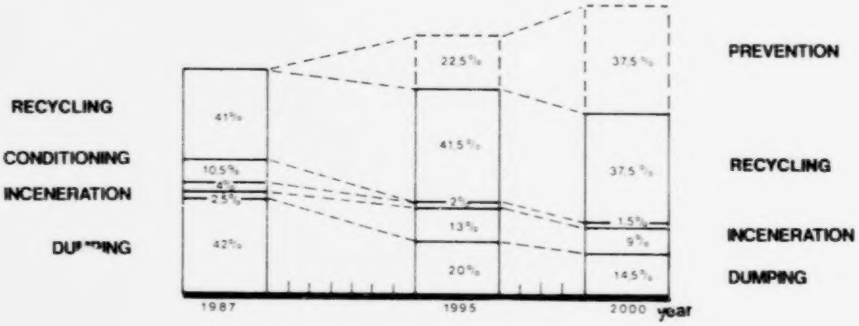
3. WASTE PREVENTION PLAN

3.1 Definition of Problems and Means

On the basis of estimated values and projected, idealized ways of disposal, figure 1 shows the relative quantities of waste which, by the early nineties, are likely to be set apart either for recycling, incineration, or dumping.

Industrial wastes subjected to some form of preprocessing (conditioning) are considered as suitable for recuperative methods. The annual increase of industrial waste, if no change of policy should occur, is estimated at approximately 2 percent.

Figure 1: A diagram of the prognosis of the offered industrial waste having to be disposed.



In comparison with the figures for 1987, preventive measures are expected to result in a reduction of overall industrial waste production of about 10 percent by 1995 and 19 percent by the turn of the century.

3.2 Objectives

Any initiative toward preventive measures must be integrated into both government and corporate management policies. Steps taken in this respect will indeed have a definite impact on nearly all levels and fields of public health, employment, finances and budget, and transportation.

To be effective in terms of prevention, the waste management planning must engage in a research program that encompasses the entire chain of production. Measures may be taken either at the producers side, that is, within the existing economical context, or on the side of the waste-processing authorities.

Since waste-disposal problems tend to become more acute the nearer one gets to the end of the production chain [mainly because that is where the buck stops (i.e., the mess can no longer be passed on] one may reasonably expect that this is where new initiatives in view of a generalized waste-prevention scheme will eventually spring up. It is, therefore, of the essence that the existing Flemish organizations and bodies entrusted with planning, research, data gathering, data-base management, information, legal aspects, and the levying of taxes be put in a position to exert a more powerful influence over the actors and factors that may affect the environment.

The attention will be focused primarily upon the further elaboration of preventive strategies, and secondly, though not less importantly, upon the stimulation of recycling, as opposed to other disposal methods.

Last but not least, coordination of waste disposal capacities will be looked into as a means to increase efficiency. The available budget shall be reserved exclusively to advocate and subsidize prevention and recovery within the industrial plant and on the domestic front.

According to the principle that the polluter must foot the bill, financial and tax incentives in respect of investments in the construction of incineration and compacting installations will be withdrawn. Financial aid going to the landfills and dump sites will be cut off. As a result, treatment and disposal processes will be billed at real cost.

3.3 Affirmative Action

3.3.1 Orientation of the Economical Expansion

Investments in new technologies that will effect a significant reduction of waste generation at its very source will be selectively encouraged through additional expansion subsidies (1 billion BF or 30 million US dollars).

Concrete proposals as to standards and criteria will be worked out between the Minister for Regional Economy and his Flemish Executive Colleague for the Environment.

In order to gain a comprehensive insight into the problematics of waste product generation, the production systems currently used in each different industrial sector in Flanders will be looked into. These audits will imply:

- A thorough inquiry into the various production areas in the Flemish region, both qualitatively (comparative merits of the production systems) and quantitatively (pollutant substance inventories, linking of emissions to immissions and to energy and raw materials consumption)
- The drafting of models to assess the quantities of waste that may be emitted without a detrimental effect upon the environment (self-regenerative powers of nature), the charting (at regular intervals) of stock inventories for all polluting substances, the verification whether previously imposed reduction quota are met
- Setting forth the outlines of an environment policy plan based on a thorough knowledge of the whole refuse cycle and a strict followup of the flux of raw materials in Flanders.

3.3.2 Stimulating Research and Development

Research and development in the field of clean technologies will be stimulated both in the stages of product design (durable goods) and of recycling potential (easily convertible materials) and in respect of most efficient production processes.

In order to prompt the development and application of clean technologies, a program of incentives was drafted, embracing the whole of the environmental problem.

Three types of projects are under review:

- Sensor projects aimed at ascertaining the feasibility of innovative ideas and rating their chances of further development
- Driver projects, focusing on a given crucial issue and searching a solution to specific environmental problems through coordination and mobilization of hitherto scattered means and know-how
- Booster projects, or live-scale try-outs in a market situation and demonstrations of a viability of new processes.

3.3.3 Agreements With the Industry

Even though regulations will retain their importance in certain areas, it must be stressed that even greater attention will have to be paid to open consultation between the authorities and the manufacturers in the major industrial sectors. Public authorities and the private sector will reach agreements with regard to possible alternative raw materials, production standards and packaging methods.

By mutual agreement, labels will be designed to distinguish refillable packages from their recyclable or single-use counterparts. Along the same lines, a prevention and recycling strategy in respect of waste byproducts in all stages of industrial packaging will be formulated.

If the targets thus set forth cannot be attained by mutual consensus within a reasonable lapse of time, antipollution taxes and penalties will be levied on one-way products and stiff deposits on returnable containers will be made mandatory.

3.3.4 Anti-pollution Taxes

3.3.4.1 Increment of the Taxes

Antipollution duties on solid waste products have proved to be an excellent deterrent, discouraging the production of trash at its source and thus favoring reduction of waste generation.

Condition to the success of such measure, however, is that such taxes be sufficiently high so as to convince the manufacturers of the financial advantages in curbing waste production. The fees to be paid would be commensurate to the amount and the nature of the trash produced.

Since October 22, 1986, taxes on industrial waste ranged from 1 BF to 100 BF per ton. On December 20, 1989, tariffs were significantly raised and presently vary between 10 BF and 3.000 BF per ton. Reckoned at these tariffs, the annual returns are estimated at 1.6 billion BF or 48 million dollars. The levies will remain at the same level until 1992, and subsequently increase.

Recycling activities, on the other hand, are tax-exempt as far as environmental duties are concerned. It ensues that antipollution taxes are also a stimuli to promote recuperation.

Dumping and incinerating will require substantial investments which, pursuant to the principle that the polluter must pay, will ultimately be billed to the manufacturers. As a result, the budget to the Flemish Executive Government will no longer have to set aside funds to subsidize incinerators or landfills. The existing incinerating facilities will be gradually renovated, but only provided the pending initiatives in relation to prevention and recovery have become fully operational.

3.3.4.2 **The Use of the Tax-generated Income**

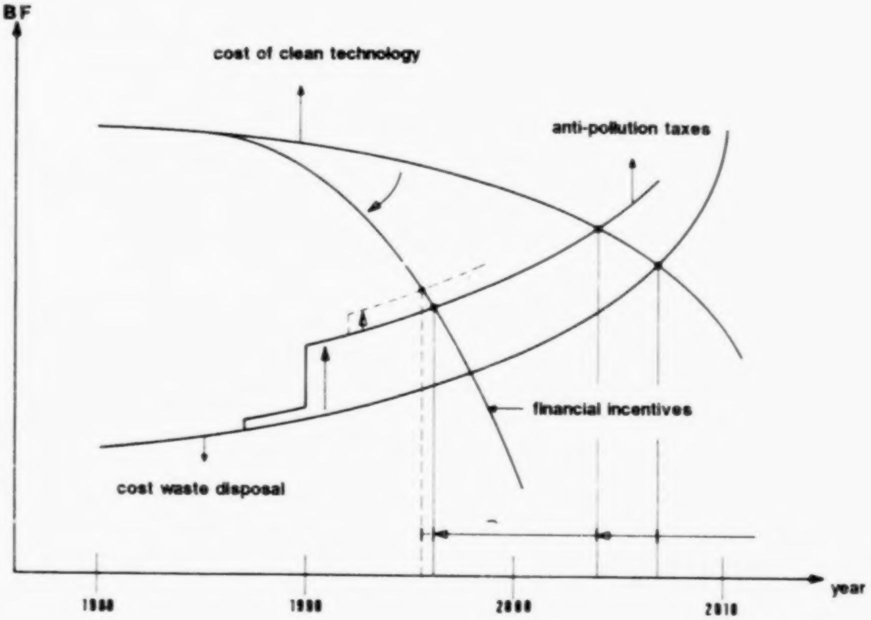
The pace of the adoption and implementation of decisions by the private sector to invest in environmental technologies (preventive action, recovery, reduced use of hazardous substances) would surely be increased if the funds collected through environment taxes are applied:

- To gain knowledge and experience in the fields of prevention and recovery and to make such know-how available to the industry

- To take part in venturesome initiatives, which at present the private sector is reluctant to take on but which are essential for health and environmental protection reasons.

The snowball effect of such ventures in lowering the threshold for the implementation of clean technologies is illustrated in figure 2.

Figure 2: The effect of the antipollution taxes and the financial incentives on the implementation of clean technologies.



The successful outcome of the measures as indicated above presupposes:

- That sharp control be exercised as to the faithful payment of the taxes
- That the manufacturers, and especially small and medium-sized businesses, be made aware of the costs of waste removal since raising the environment taxes will not automatically induce such private enterprises to take immediate steps to switch to clean technologies.

By increasing the predictability of running cost increments, manufacturers will be enabled to anticipate future developments.

The strongest incentive for the industry to invest in environmental technologies will be the firm belief in a consistent, gradually stepped-up, and generally enforced ecological policy on the part of the authorities.

3.3.5 Licenses

A rigid licensing policy constitutes one of the most powerful instruments in the prevention of harmful emissions. The generation of waste byproducts (viewed in terms of quantity and chemical composition) should be regarded as one of the prime considerations for granting of withholding operation permits and subjecting production to stringent conditions. In its advisory capacity regarding the issuing of licenses and permits, OVAM, the Public Waste Management Authority for the Flemish Region, firmly intends to take into account the efforts made to check waste production.

3.3.6 Spreading Awareness

The sensitization campaigns are designed to inform and to impress upon the industries, and, in particular, small and medium-sized businesses, the notion of the necessity of a sound waste management as an integral part of general management.

OVAM intends to elaborate a standard method for imparting new attitudes and understanding about environmental issues that will be made available to interested parties.

3.3.7 International Contacts

Along the lines of the international contacts of the Flemish Executive Minister, OVAM will cooperate, as far as waste (solid liquid sludge) management is concerned, with the EC, the Eastern European countries, the Organization for Economic Cooperation and Development and the UNEP.

4. CONCLUSION

If this ambitious goal (i.e., preventing the generation of waste substances) is to be achieved, government-inspired actions will have to focus on:

- Acquiring knowledge and experience
- Centralizing and disseminating relevant information

- Giving financial aid to businesses either manufacturing or using nonpolluting products.

The conversion of existing industrial activities or launching of new activities will have to comply with the premises of a future ecologically safe operation permit that will incorporate and replace current permits and that will put the highest premium on waste prevention. Ecologically sound products and processes will benefit from expansion subsidies provided both waste generation and raw material flux are adequately controlled and checked.

WATER POLLUTION PREVENTION IN THE NETHERLANDS

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SUMMARY

According to some recent environmental policy documents a further and especially a faster reduction of the pollution of the surface waters by the industry is necessary.
From an analysis of the common practice in licencing it is indicated that the water authorities should pay much more attention to other fields than just technologicy in order to take away the barriers for the use of clean preventive measures. Nine points are indicated which are necessary to improve the use of preventive measures. Implementation of this preventive approach should result in a new preventive pollution reduction policy.

INTRODUCTION

There is a lot of water in the Netherlands. Besides this the country is also densely populated and highly industialized. This has resulted in pollution of surface waters and sediments. For some decades however a lot of effort has already been given to the abatement of poor water quality, resulting in a steady increase of the water quality.
Recently some new national and international policy documents have been published indicating strict targets to be achieved within a couple of years. These targets can hardly be achieved by continuing the common practice of waste water abatement. So another way to cope with these problems has to be found.
In this article the Dutch policy for reducing water pollution is given, as well as the barriers for clean technology in industry and the approach to overcome these barriers in order to promote the use of clean preventive technology.

POLICY

The legal framework to combat water pollution in the Netherlands is provided by the "Pollution of Surface Waters Act" Section I of the Act states that it is prohibited to deposit waste, pollutants or noxious substances in surface water, unless a permit has been granted.
Two basic principles are used in granting licences (1):
- reduction of emission;
- stand-still principle.

These two basic principles have been worked out into the so called:
- direct emission approach;
- the water quality approach.

The direct emission approach has been worked out in the concept of the "best technical means" and the "best practicable means". The best technical means must be applied for black list substances, while for other substances, to which the emission approach applies, the best practicable means must be applied.

The best practicable means (BPM) are technologies by means of which the largest reduction of emission of polluting substances is obtained once due allowance has been made for economic aspects, i.e. what is acceptable from a financial point of view for a normally profitable company.

The best technical means (BTM) are technologies which produce a greater reduction than BPM at a greater expense.

A certain residual emission is regarded as acceptable for the purpose of applying BPM, provided that the water quality objectives are met.
When applying BTM a residual emission is in principle unacceptable and water quality objectives are not a point of consideration.
This does not mean that financial aspects and business economics should not play any role at all in the application of the best techniques available.
The "standstill principle" is related to the water quality approach. The water quality may not significantly deteriorate. Table 1 gives an overview of the application of concepts and technologies in relation to the substances emitted.

The above mentioned "black-list-substances" correspond with the list in directive 76/464/EEC of 4 may 1976 of the European Community .

All this briefly outlines the policy, untill 1988, when the Rhine Action Program (2) and the North Sea Action Program (3) came into force.
These programs, in which several European countries work together, were initiated because of the common concern about the quality of these watersystems. These programs aim at a reduction of certain specified substances. The target is now a reduction of 50% for all pollutants and 70 to 90% for some organic micro-pollutants, within the time-period 1985-1995.

Besides these source reduction targets the National Policy Document on Water Management (6) sets limits for the so called "general environmental quality". These quality standards for several compounds in water and/or sediments are based on ecotoxicological criteria. These standards are much stricter than the standards in the Water Action Program of 1985 (1).

In working out this policy in daily practice the aim is to obtain a uniform approach for companies as far as possible. There can be small or medium-sized companies in certain industrial sectors doing the same type of work in more or less the same way.

If this is the case the same provisions to discharges and more or less the same conditions can be used in the discharge licence of all these companies. This results in emission standards for certain sectors of industry, such as the metal-plating industry. For more complex industries like the chemical process-industry the differences between companies can be big, because of different recycling and treatment possiblities available. So the licences of these industries can and will differ significantly. For all companies, big and small, individual "tailor made" permits are granted to obtain the smallest emission possible.

These permits are granted by the local water authorities. In order to maintain a common approach to dischargers all over the country the National Institute for Inland Water Management and Waste-water Treatment acts as one of the main advisors of these authorities.

Not only reduction of the emissions into the water is needed. From the National Environmental Policy Plan (5) it is clear that emissions into the air, the soil and the amounts of (hazardous) waste should be reduced. Especially for solid waste a prevention plan has been set up.
The combined environmental policy results in a strong appeal on companies to change their behaviour.

COMMON PRACTICE

To achieve certain emission reductions the Waterboard starts negotiations with the company involved, resulting in a emission reduction plan submitted by the company.
The main objectives of the plan, the emissions standards to be achieved, as well as the timeschedule are put into the licence, if they are accepted by the Board.
In this process of negotiation the water authorities will first pay attention to the production process itself.
The policy mentioned above gives the authorities the possibility to ask for the environmentally best processes and equipment, according to the BPM and BTM-principle. For example the installation of a chlorine production unit based on mercury electrolysis will not be permitted because of the proven membrane-process, which avoids the emission of mercury. Unfortunately new/alternative processes are often not taken into account because of the financial uncertainties, product quality, the time-pressure to reduce the pollution, etc.

The second subject in the "permit-negotiations" are the raw and auxiliary materials used. For example the use of certain qualities of phosphate-ores in the fertilizer industry can dramatically influence the quality of the waste water. By using the good qualities available smaller amounts of cadmium will be emitted.
So in the licence the reduced cadmium amounts which are the result of the better ore-quality will be stated. Of course the

company is free to use ore of lesser quality, if additional measures are taken and the set emission limits are not exceeded.

The auxiliary chemicals used should be reviewed also in order to avoid the ones which are most harmful to the environment. In the Netherlands the textile-finishing industry has created a database for this purpose. In cooperation with the water authorities certain "black" chemicals will be selected and replaced if possible. Because of the large number of chemicals the possibilities are unfortunately not always checked.

If all possibilities of process changes and internal recycling have been paid (more or less) attention to, waste water treatment comes into discussion as a major aspect.

Besides legislation the Government has some other instruments to stimulate the abatement of waterpollution.
First of all levies based on the emission of the oxygen demand of the discharged waste water are used to finance subsidies for measures taken by local water boards and companies.
This results mainly into end-of-pipe treatment, in which the suppliers of (standardized and low-priced) equipment play an important role.

There is also a special subsidy to stimulate the development of clean technology. This Governmental subsidy is given for research projects for which the laboratory stage has been completed, but where practical implementation is restricted by the technical and/or economical risks involved. Projects that qualify for such assistance must have certain novel technological features, must be beneficial to the environment and have the potential to be applied on a relatively wide scale. It is hoped that government subsidized research of this type should reduce the risks mentioned. In addition, the Dutch government also supports demonstration projects involving clean technology. (7)
Examples of clean technology project are:
- substitution of cadmium in the metal plating industry;
- the development of a clean phosphate fertilizer production process;
- measures to improve fish processing techniques.
- electrochemical treatment of process waste water containing halogenated organic compounds;

Nevertheless the spin-off of these projects is rather low, because there is hardly any enforcement by the government to invest in clean technology rather than in end-of-pipe-treatment. Not even if the expences are equal. Secondly the companies are not aware of stricter regulations in the (near) future. In the third place transfer of the generated know-how is insufficient.

Looking at these instuments (legislation and subsidies) the possibilities to promote the development and subsequent use of clean technology seem to be present. Nevertheless the results are poor.

The emissions of pollutants from the industry are reducing, but too slowly to achieve the targets set in the policy plans.
So a new approach is required.
Realizing that the targets can only be achieved if more preventive measures are used, the barriers for clean technology should be known.

PREVENTIVE APPROACH

Licencing is considered the most direct way to influence companies. So a project was set up to figure out the prevention prohibiting points in this process.
The way the licencing process is run by the waterboard and advise is given by the Institute now and the way it should be run and advise should be given to obtain more preventive results in the near future was analysed using the Integrated Definition-method (IDEF). This analysis was carried out in close cooperation with the Netherlands Organization for Applied Scientific Research (TNO) (4).
The analysis resulted in nine points which need the attention of the Water authorities in order to achieve more preventive measures taken by the companies.
These functions are summarized below.

1. Necessity of measures.
It was observed from the analysis that normally not everybody involved is fully aware of the need to reduce certain emissions. This can cause a problem in introducing measures. E.g. local politicians may support the company in its resistance to invest in certain environmental measures if they not fully understand the reasons.
So first of all the necessity of measures must be clear to all the parties involved. This includes the companies and the authorities in charge of other fields than waterpollution, e.g. air, soil, safety, etc. If these parties know and agree on the necessity of measures, targets can be set and may be expected to be firmly supported.

2. (Non)technological know-how.
Untill now the problems met in emission reduction are approached from the technological point of view. The technological know-how should ofcourse be up-to-date. But other fields are almost ignored, although these fields play important roles in the decisions on investments.
From the analysis it is clear that know-how on environmental effects of chemical substances, policy-making in other departments, technological aspects of preventive management, environmental management, decision-making and economics in companies and in industrial sectors are necessary to successfully introduce preventive measures. Special attention should be given to the possibilities to change the attitudes within companies into

a higher level of environmental awareness.

3. Discharge standards.
Companies always complain that the government uses the vague concepts of "Best Practicable Means" and "Best Technical Means" in demanding efforts on emission reduction, in stead of setting clear limits to be reached within a certain perio of time.
The analysis indicated that permits which did not contain discharge-standards (preferably for a period of several years) can be prevention prohibitive. Also an over tight time schedule for the reduction of emissions will force companies to look for existing possibilities. Mostly these will turn out to be end-of-pipe treatments. (E.g. "I will not change a big part of my process, if you cannot assure me that you or one of your colleagues will not be back with new demands within the next 10 years".)
So it should be made clear to the companies which discharge-standards they will have to meet in the (near) future for all environmental compartments involved.
These standards must be coherent and there must also be a time-path to come from the present situation to the situation indicated.

4. Company specifics.
The specific information about the company which the Waterboard depends on in the negotiations about the implementation of emission reduction measures, is mostly not very much more than that which the company itself has offered. So the Board can hardly support suggestions for drastic changes by arguments in terms of pro's and con's of the specific situation.
According to these observations know-how on technology, economic feasibility of process-investments, organisation of the decision-making on investments is necessary to be an acceptable partner in the negotiations with the companies or sectors of industry involved. Also some knowledge of the companies' culture and the way the company is organised will be very usefull.

5. Consistency of policy.
Evidently there is a gap between policy-makers and the people who execute the policy in the day-by-day contacts with individual companies. This gap should not be too large. The companies will not rely on statements made by the executors, if the policy-makers speak loudly about another (stricter) policy. So to create an atmosphere of mutual trust, it is necessary that within the water compartment all authorities involved speak the same language. The policy of abating water pollution should be clear to all involved. In fact, in the negotiations with the companies all authorities, not only from the water compartment, have to work coherently from the same back-ground. (see also point 3).

6. Consistency of regulations.
The analysis performed pointed out that the environmental regulations are not always very consistent. The authorities

involved should be aware of gaps, resulting in undesired (non-preventive) solutions of the environmental problems.
Regulations for the different environmental compartments have to be coherent. Also the fine-systems have to be coherent and consistent. "Internalization" of companies regarding the environmental effects of their activities might be necessary to overcome inflexible regulations.

7. Transfer of know-how.
The analysis clearly indicates that companies are not always aware of possible process-technological improvements. Especially in the smaller companies there is a lack of know-how on process technologies. Alternative processes, improved process units and so on are unknown. Most reports written by environmental authorities and/or private consultants on these subjects are addressed to the same or other authorities. These reports are often not easily available for small companies and/or not easily understandable for the people in these small companies. So to improve the use of preventive measures the authorities have to take care of the transfer of the necessary know-how.

8. Quality control.
Mistakes during the production-process can easily result in huge spills into the environment, slightly increased direct discharges, as well as emissions into the environment elsewhere within the product life-cycle, caused by reduced quality of the product itself. Control systems on the "environmental quality" of resources, process operations and products have to be incorporated in the common product quality control systems.

9. Governmental discharge control.
The number of checks carried out by the authorities on the discharges is limited. The first purpose of any entrepreneur is making money. So care for the environment will take second place at best. In this case circumstances of non-compliance with the discharge-standards will occur.
The government should create an instrument to minimize the companies' opportunities for non-compliance. Besides a strict environmentally directed quality-control-system (see 8) within the company itself, which can be checked by the authorities effluent-monitoring might be usefull.

The nine functions, all of which have to be fulfilled for the implementation of preventive management in private companies, are in all their coherences depicted in figure 1. In the centre are the two main items for preventive management: "investment in advanced process technology" and "the daily process operation".

IMPLEMENTATION

From the resulting "preventive approach" it can be concluded that there are clearly other barriers, besides financial uncertainties.

In order to implement the proposed approach, information is needed on fields in which neither the Institute for Inland Water Management and Waste water Treatment nor the Waterboards usually have much experience, such as economy and other non-technological fields.
Therefore a project will be set up to investigate what kind of knowledge exactly is needed and where it is available.
This project (8) will be set up in close cooperation with the researchgroup of Prof.D.Huisingh of the Erasmus University Rotterdam.
Primarily the aim of the project will be to bring about attitudinal changes in environmental management and decision-making by giving examples and by influencing the attitudes of both companies and authorities.
To gain experience with this new approach in practice some cases-studies will be set up with selected companies.
Complementary to the approach mentioned these studies will be enhanced by the experiences gained within the Pollution Prevention Pays-concept.
The results of this cooperation should contribute to establish a new preventive, pollution reduction policy.

CONCLUSION

According to the present waste water abatement policy in the Netherlands, sharpened by the Rhine Action Program and the NorthSea Action Program a further and especially a faster reduction of the sources of pollution is necessary. To obtain this reduction at one of the sources (industry) preventive measures are needed.
From an analysis of the common practice in licencing it is indicated that the water authorities should pay much more attention to other fields than just technology in order to take away the barriers for the use of clean preventive measures.
Nine points all of which have to be fulfilled for the implementation of preventive management in private companies are indicated to improve the use of preventive measures:

1. Prove the necessity of the emission reduction to all people involved.
2. Improve not only the available technological know-how, but also the know-how in the fields of e.g. economy, sociology and decision-making.
3. Stipulate discharge-standards and time schedules.
4. Improve company or industry-specific know-how.
5. Organise consistence between policy-makers and policy-executors.
6. Define consistent regulations and fine-systems
7. Take care of the transfer of (preventive) technological know-how, especially to smaller companies.
8. Demand quality-control-systems within the companies.

9. Set up or improve the governmental control system of discharges.

The generated nine points preventive approach will be worked out in a project together with the Erasmus University Rotterdam.
As major part of this project some case-studies at selected companies will be carried out.
All this should result in a new preventive pollution reduction policy.

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TABLE 1. OVERVIEW OF THE APPLICATION OF CONCEPTS AND TECHNOLOGIES IN RELATION TO THE SUBTANCES EMITTED.

Type of substance	Blacklist substances	Other pollutants	
	specific organohalogen compounds mercury cadmium etc.	heavy metals oxygen-consuming substances phosphate nitrate	sulphate chloride heat
clean up primarily on the basis of	emission approach	emission approach	water quality objectives approach
measures on basis of	best technical means	best practicable means	acceptability of discharges and steps to be taken depending on the water-quality objectives aimed at.
any further requirements based on	unacceptable concentration in the aquatic environment	water-quality objectives	

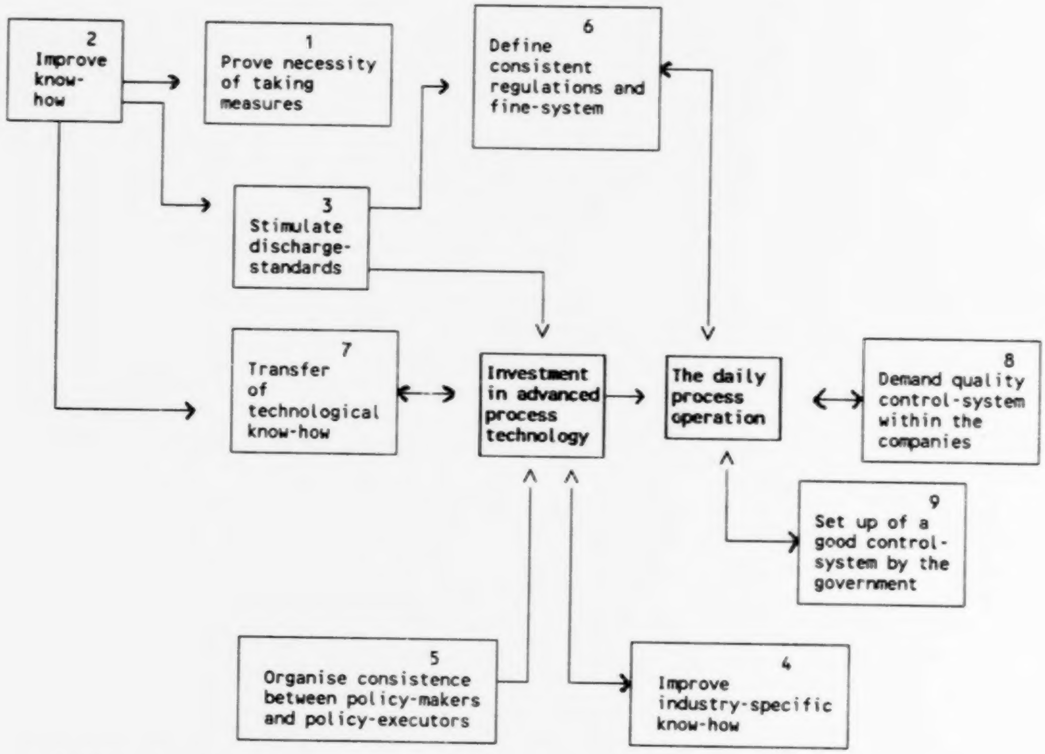
2 Improve know-how
1 Prove necessity of taking measures
6 Define consistent regulations and fine-system
3 Stimulate discharge-standards
7 Transfer of technological know-how
Investment in advanced process technology
The daily process operation
8 Demand quality control-system within the companies
9 Set up of a good control-system by the government
5 Organise consistence between policy-makers and policy-executors
4 Improve industry-specific know-how

Figure 1. The nine functions for preventive management.

New Directions in Waste Minimization Technologies: Water Conservation Offers Multi-Faceted Benefits

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Introduction

Over the past decade, innovative technologies and advances in water supply management have demonstrated that the science of water conservation has much to contribute to the emerging field of pollution prevention. Numerous case studies show that reductions in water demand significantly reduce energy, natural resource use, waste generation, wear and tear on system infrastructure, and deterioration of water quality. Conservation also benefits both water supply and wastewater systems, such as publicly owned treatment works (POTWs). In addition, the more efficient use of water can help stave off the destructive political conflicts that are often associated with water supply management today.

This paper explores the techniques and benefits of water conservation and outlines recommendations to help integrate them into future utility management and pollution prevention programs.

Growing National Water Shortages

Once relegated to the vast dry regions of the western United States, water supply problems now affect virtually every major urban region east of the Mississippi. Record droughts and shortages are now occurring in parts of California and Florida. According to the U.S. Congressional Budget Office[1], 170 of the nation's 756 large urban water supply systems now need additional supplies. The era of easy water developments is over: economic constraints, environmental concerns, and political conflicts have significantly hampered development of new large sources. Further, the EPA's recent decisions to use Section 404 of the Clean Water Act to prohibit new source development proposals in Denver (Two Forks Dam) and Rhode Island (Big River) are indicative of a potentially far-reaching federal role in water supply expansion decisions.

As new water supply options dwindle, many communities are finding that water conservation can serve as a valuable complement or alternative to supply-side strategies. And on the other side of the water equation -- wastewater -- many POTWs are finding that loads can be reduced by conservation programs. The implementation of system wide conservation programs is being shown to reduce water and wastewater facility operating costs and their associated environmental burdens. Moreover, such conservation efforts have sometimes resulted in the deferral of capital expenditures and resources for new or expanded water and wastewater treatment facilities.

Water Demand Strains Many Resources

The production of potable water for public, agricultural, industrial, commercial, and recreational use, as well as the treatment and management of the resulting wastewater loads, takes a toll on the environment. The costs have hardly begun to be assessed. They involve extensive infrastructure, land, energy, chemicals, and intrusion upon the natural ecology of surface and groundwater sources. While modern sanitary engineering has provided dramatic improvements to public health and the environment since the cholera epidemics of the turn of the century, wastewater treatment plants with their enlarged system capacities to serve our ever-growing population nevertheless strain their receiving environs. Further, water is often the vehicle for pollution from inefficient industrial processes and agricultural applications involving excessive chemical and energy use.

Water Conservation Comes of Age

Where conservation was once viewed as a temporary means to achieve demand reductions during droughts or other water emergencies, the modern "science" of conservation has created new means to achieve permanent and substantial water savings. Since the late 1970s, water conservation "tools" have grown beyond public education campaigns promoting voluntary reduction in water use to the development of water-efficient plumbing fixtures and appliances, cooling equipment, industrial processes, turf and irrigation methods and equipment, and other measures. In addition, advanced computer forecasting models and statistical techniques have been developed for more accurate assessment of water use and costs.

Conservation Technologies & Benefits: Some Case Examples

Experience has shown that most water utilities can reduce their water demand and wastewater loads from 5 to 15 percent by implementing a comprehensive demand reduction program.[2] Conservation strategies, encompassing both hardware and behavioral changes, are available for each water use sector. The strategies that result in the most water savings are described below:

Plumbing Fixture Retrofit. Installation of water-efficient plumbing fixtures -- toilets that use 1.6 gallons per flush (gpf), showers that use 2.5 gallons per minute (gpm), and faucets that use from 2.0 to 2.5 gpm -- can significantly reduce residential and sanitary water use. The total estimated annual household water savings from a retrofit of conventional toilets, showerheads, and faucets range from 13.5 gallons per capita per day (gpcd) for replacement of fixtures installed after 1980 to 33.5 gpcd for pre-1980 fixtures. For a typical 2.7 person household, these savings range from 13,300 to 33,000 gals/year, a savings of 39 to 61 percent over the present estimated household budget of 34,000 to 53,700 gal/year for high water-use fixtures.[3]

Case Study: Santa Monica, Calif. To help conserve supplies and reduce loads on the Hyperion wastewater treatment plant, the city of Santa Monica, California has initiated a program to replace 12,000 conventional toilets with low-flow fixtures; anticipated savings are 835,000 gallons per day (gpd). The city plans to use the old toilets to construct an artificial offshore reef in Santa Monica Bay to attract fish and vegetation back into the area.

Industrial/Commercial. Water is used by industry and commercial establishments primarily for cooling, process water, sanitation, and landscape irrigation. Cooling-water needs have been estimated to account for about 70 percent of the gross water use of chemical-process industries nationally. Often, cooling water is uncontaminated and can be reused for landscape irrigation, cleanup, and other purposes. Replacement of once-through cooling processes with recirculated systems has been shown to provide some of the largest water savings and the most rapid investment payback.

Case Study: San Jose, Calif. In 1985, the city of San Jose, California, began a 10-year conservation plan with a goal to reduce wastewater flows by up to 12 million gallons per day (mgd) in order to delay a $180 million expansion of its San Jose-Santa Clara Water Pollution Control Plant (WPCP). All user sectors -- residential, commercial, industrial, and institutional -- were involved. At that time, system demand was growing at a rate of about 3 mgd per year. As part of the city's program to reduce wastewater flows, 15 companies in the electronics manufacturing, metal finishing, paper processing, and food processing industries were surveyed to assess the water, energy, and chemical cost savings realized from their conservation efforts. Conservation measures by the companies reduced water consumption by more than 1 billion gallons per year. Economic benefits from the conservation steps resulted in a combined savings of about $2 million per year. The most common conservation measures taken by the companies were: water use monitoring, recycling, reuse, cooling tower use, equipment modification, improved landscape irrigation, and employee education. Some of the electronics manufacturing and metal finishing companies surveyed were able to reduce their use of chemicals by reusing makeup and rinse waters that they had previously discharged and rebatched. While total operation and maintenance cost savings achieved from the entire demand reduction program will not be known until 1995, it was originally estimated that over $40 million in gas, electricity, chemical treatment, and associated system operating costs would be saved if the 12 mgd goal was reached.[4]

Landscape and Turf Management. Significant water savings can accrue from more efficient residential lawn watering and landscape irrigation for public parks, office parks, cemeteries, golf courses, and road meridians. About 50 percent of residential water demand goes to outdoor use, mainly lawns, gardens, and other landscaped areas, and studies have shown that most homeowners typically provide twice as much water as is actually needed. Homeowners who modify their irrigation practices can reduce their turf water requirements by 30 to 60 percent without sacrificing the quality of their lawns. Reduced watering is further beneficial to the health of a lawn because waterlogged turf increases it's susceptibility to disease.

Lawn and landscape areas are typically overwatered because of faulty irrigation systems or because of ignorance of its true water requirements. The efficiency of typical landscape irrigation methods has been estimated to be 50 to 80 percent.[5] Better availability and proper use of ET[a] data and moisture sensors to normalize outdoor irrigation for local weather conditions can help reduce outdoor watering. Another low-water-use landscape measure is xeriscaping, a term referring to the application of environmental-appropriate horticultural practices. Xeriscaping involves seven principles: (1) proper landscape design, (2) soil improvement, (3) use of mulches, (4) reduction of turf areas, (5) zoning irrigation systems, (6) selection of low-water-demand plants, and (7) attentive maintenance. Xeriscapes have been developed extensively in California, Florida, and the southwestern United States.

Case Study: North Marin Water District, California. In 1985, the North Marin Water District conducted research on the use of water, labor, fertilizer, fuel, and herbicides in traditional landscapes in planned housing developments (townhouses and condominiums). While the dollars savings attributed to decreased fuel and herbicides were small, study results showed that significant savings could be realized by the use of a water conserving design. Homes with water-conserving landscapes used 54 percent less water monthly than homes without, and this reduction in water and labor costs accounted for more than 80 percent of the total savings. Estimated cost savings to the homeowner were $75/year.[6]

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[a] Evapotranspiration describes the total water used by a lawn. The rate at which it is used is called the "ET rate"--water applied in excess of ET is not used by the lawn, and thus is wasted. The two factors that largely determine ET rate and, hence, the lawn's water requirements, are grass species and climate.

Measuring the Economic and Environmental Benefits

Determining the economic savings and beneficial environmental impacts of water conservation can be a complex process. For instance, the marginal cost of resources to produce (treat, pump, and dispose) an additional unit of water and wastewater can be identified for a particular utility. Such costs are typically for energy and chemicals. Nationally, the average marginal cost of water supplied is about $1.00/1,000 gallons, and $1.50-$2.00/1,000 gallons for wastewater collection, treatment, and disposal. But the less obvious long-term capital benefits from conservation, such as the downsizing of pipes because of decreased residential water demand or the decreased wear-and-tear on infrastructure from more efficient system loads, are just beginning to be assessed. Further, the benefits of reduced environmental impacts are not easy to gauge since they affect many ecological systems and it is difficult to isolate the influence of one source. The environmental and economic advantages of conservation are outlined below:

Water. Preservation of natural surface water and groundwater hydrologic balance, including free-flowing rivers and streams, wetlands, freshwater fisheries, and related wildlife habitats and species.

Wastewater and Septic Systems. Decisions to postpone or not to expand or build new water supply systems lead to reduced need for related wastewater facilities and result in cost savings. The reduced wastewater volumes associated with water conservation can also extend the life of an overloaded septic system. This will delay or eliminate the need to expand existing drain fields, allow future systems to be smaller, thereby preserving land area and reducing system installation costs. Some communities allow for reduced hook-up fees and utility charges where water efficient fixtures are used, bringing direct cost savings to the customer.

System Operating and Capital Costs Reduction. Reduced water demand leads to decreased water supply needs and reductions in the associated capital investments and operating costs. Reduced water demand will also lessen wastewater loads and lower unit costs for wastewater collection, treatment, and disposal. Conservation can also result in less wear-and-tear on system and prolong the life of the system infrastructure. Facility expansions can be delayed and sometimes averted; the resulting cost savings could be applied to help stabilize utility costs or upgrade existing facilities.

Water Quality. Water conservation is inextricably linked to the preservation of water quality, particularly for well-drawn groundwater supplies. By decreasing the rate at which groundwater is pumped, water conservation can reduce the rate of infiltration of such contaminants as saltwater, septic leachate, leakage from underground storage tanks, hazardous wastes, and other pollutants into an aquifer. Slowing this rate of infiltration could have a significant impact on the viability of a groundwater supply system serving public drinking water needs.

A good example of the link between water quality and water conservation is the city of Fresno, California, a community of 270,000 people in the center of the agriculturally rich San Joaquin Valley. A history of heavy groundwater pumping and the use of agricultural chemicals in the surrounding area have created a water crisis in Fresno. According to David Todd, Water

Conservation Coordinator for Fresno, overpumping by the City is pulling contaminants toward wellfields.[7] The city has had to close 34 wells because of contamination by dibromochloropropane (DBCP), an agricultural pesticide. As a result, Fresno is trying to reduce water demand and slow the migration of contaminants toward other wells in the area. The City Council has voted to retrofit 81,000 single-family homes with water meters and also advocated the use of 1.6 gpf toilets in all new construction. Community leaders hope that these and other vigorous conservation measures will buy them time to find new, uncontaminated sources of water for Fresno.

Agricultural Productivity. According to Sandra Postel, Vice President for Research at the Worldwatch Institute, "Most of the vast quantity of water diverted by and for farmers never benefits a crop: worldwide, the efficiency of irrigation systems averages less than 40 percent." She goes on to describe the ecological toll of excessive irrigation: "By far the most pervasive damage stems from waterlogging and salinization of the soil....[O]verwatering of fields raises the underlying groundwater. Eventually, the root zone becomes waterlogged, starving plants of oxygen and inhibiting their growth. In dry climates, evaporation of water near the soil surface leads to a steady accumulation of salt that also reduces crop yields."[8] Also, in the last few decades, excessive irrigation has washed high levels of toxic selenium out of the soil, a process that would have taken centuries with natural rainfall. In the U.S., more than 4 million hectares - approximately 20 percent of the nation's irrigated land - are watered by pumping in excess of recharge.[9]

The Lower Colorado River Water Authority (LCRA) has developed an aggressive agricultural water conservation that has reaped substantial water savings and related benefits. LCRA own and operates two irrigation canal systems which together supply water to irrigate about 60,000 acres of rice each year. Rice irrigation is the largest use of water within the areas served by LCRA, and it generates an income of approximately $300 million per year. In 1987, LCRA initiated a conservation program to reduce water use for rice irrigation. The LCRA program consists of four major activities: canal rehabilitation, on-farm conservation research, farmer education, and farm water measurement. These conservation measures have thus far reduced water use for rice irrigation by approximately 70,000 acre-feet or 25 billion gallons a year. This represents approximately 70 percent of the City of Austin's water use each year, or enough water to serve the demands of a city of 300,000 people. LCRA has estimated that rice irrigation water demands can be further reduced by another 65,000 acre-feet in the years to come. Other benefits from the program include: reduced costs to pump water, lessened risk of water shortages during drought that could jeopardize rice irrigation needs, higher lake levels for recreation, and improved farm productivity and profitability.[10]

New Building Construction Savings. Reduced water and wastewater volume loads on buildings will allow downsizing of water and sewer service lines and help reduce construction costs and costs for pipe.

Sustainable Growth. Throughout history it has been shown that the maintenance of a prosperous and healthy civilization hinges, in part, on its ability to maintain sustainable resources and development. The conservation of water is insurance for future prosperity and continued growth because it balances supply with demand, and makes water a renewable resource. Every home, industry, or farm equipped with water-efficient fixtures, equipment, or using sound irrigation practices will extend existing water supplies for future development.

Conclusions and Recommendations

In order to ensure sustainable water supplies for this country's future, as well as minimize the associated use of chemicals, energy, and other natural resources, we must lower the demand side and promote conservation as the most cost effective and efficient supplier of choice. We need strategic planning on the federal, state, and local levels to develop renewable water resources and to reduce wastewater generation. A comprehensive assessment of the benefits associated with water conservation needs to be developed and publicized. The EPA's leadership in the development of policy and programmatic and educational assistance in the area of conservation and integrated water resources management is clearly needed by both the public and private sectors. As part of that effort, the following recommendations are provided:

1. The total water, energy, and waste minimization benefits of water conservation need to be assessed. A model to identify all the factors and impacts of conservation should be developed and made available to communities and water and wastewater utilities.

2. Water conservation efforts should be focused on the biggest users so as to ensure the largest and most cost-effective savings. A number of sophisticated and proven benefit/cost models are available to assist in this regard. The Metropolitan Water District of Southern California and the South Florida Water Management District are both good examples where such analysis has been applied.[11]

3. Water conservation programs should be combined with industrial and commercial toxics reduction programs as they are mutually beneficial. Pretreatment programs should have incentives that include conservation. Currently, many states' industrial pretreatment programs have disincentives to conservation since they measure contaminant outflows per unit of water instead of total concentration.

4. Federal support of proposed national plumbing standards for water-efficient plumbing fixtures and appliances is needed now. The "National Plumbing Products Efficiency Act" (H.R. 1185/S.583), now pending in the U.S. Congress, would establish water-efficient plumbing standards nationwide. Passage of this legislation would reduce daily U.S. water use by 3.4-8.4 billion gallons a day if fully implemented in 1990. Currently, more than 10 states and major cities have enacted laws or plumbing codes to require the use of 1.6 gpf toilets, 2.5 gpm showerheads, and 2.0 gpm faucets. However, federal standards are needed to ensure the nationwide availability and installation of water-efficient fixtures.[4]

5. Development of national guidelines and incentives programs to promote water conservation is necessary to heighten public awareness about the need for and benefits of conservation.

6. Federal and state properties should be assessed to determine their potential for water and economic savings from conservation measures. Substantial taxpayer dollars are spent on maintaining federal and state housing authorities, institutions, military installation, and other facilities.

7. The disincentives to conservation - pricing inequities, ignorance, and resistance to new engineering approaches need to be eliminated. Many water utilities still do not charge their customers for the true cost of water services and the same is true for wastewater. Hence, the economic burden is unfairly distributed among certain user classes and taxpayer groups. Historically, water conservation has been a low priority for many large users, such as industrial

customers, since they often pay for water and wastewater service on a declining block rate structure that offers a more favorable per unit charge compared to smaller users. They lack an incentive to reduce their water demands and wastewater loads. In addition, in the future we must set water rates not only by volume but also by efficiency of use.

8. Agricultural irrigation needs to be examined to develop more efficient equipment standards and practices. Further, the impact of water use efficiency on food production needs to be assessed.

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PROCESS OPTIONS FOR WASTE MINIMIZATION AND METAL RECOVERY FOR THE METAL FINISHING INDUSTRIES

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ABSTRACT

There is growing environmental concern with the methods of waste disposal used for handling hazardous materials in the metal finishing industry. A resulting need exists to develop and implement the best existing and potential technologies for waste minimization and resource recovery. The objectives of this study were to identify and briefly describe both existing and potential future methods for minimizing and recovering metallic wastes in the metal finishing industries. Included in the evaluation are the advantages and disadvantages of the various methods available and under development. Existing minimization techniques include countercurrent rinsing, drag-out reduction, and waste segregation. Recovery methods investigated include evaporation, ion exchange, reverse osmosis, electrodialysis, and re-smelting of metallic wastes. Discussions on future methods also cover combination technologies with the trend toward development of closed-loop processes. Investigation has shown that additional research must be done to make the developing technologies economically feasible. These challenges are being met by increasing contributions from the technical community, particularly chemical engineers. Finally, the metal finishing industries must be willing to join in the development and implementation of these new technologies if we are to successfully answer environmental concerns.

BACKGROUND

Electroplating of metals became feasible in 1840 and has grown until it now ranks as an important specialty industry, with nickel, copper, and chromium as examples of the most important plating metals (1). Electrodeposited metals serve either a decorative or structural purpose, or sometimes both, by providing a pleasing appearance and/or various desirable engineering properties. Electroplating finds application in many areas, including electronic, automotive, aerospace, and household products.

An example of this dual purpose application is chromium plating, which has both decorative and "hard" or industrial-use. These hard chromium coatings possess such desirable engineering properties as heat, wear, corrosion and erosion resistance, and a low coefficient of friction (1). Chromium is deposited primarily from a chromic acid (CrO_3 as H_2CrO_4) solution, which is highly toxic.

A major concern in metal electroplating is the high toxicity of plating chemicals and, therefore, the process requires extensive measures to prevent release of hazardous material to the environment. Releases come primarily from discharge of improperly treated rinsewater, though spray from the plating bath surface (particularly while using aeration for mixing), spills, and occasional plating bath disposal (because of uncorrectable composition) can also be of concern. In addition, since chemical precipitation of heavy metals is the primary method of treatment of these waste materials, disposal of hydroxide sludge is a significant problem. When confronting these problems, concern must include the short and long-term effects on the health of the plating shop workers and the public in general.

Concern for public safety has lead to growing environmental regulations on the federal, state, and municipal levels. Regulations include the Resource Conservation and Recovery Act (RCRA) and the Hazardous and Solid Waste Amendments of 1984 (2,3). As with all manufactures, the plating industry must deal with unfounded fears of the public about anything involving chemicals, especially when the chemicals are deemed "toxic" by public institutions, such as the government or the press. To command public confidence, not only must we continue to responsibly handle these hazardous materials, but we must make our successes known to the public, which, at a technical level, will involve developing improved means for disposal and ultimately recovery of valuable resources through process improvements and new technologies.

The minimization, recovery, and treatment methods employed for wastes produced by any electroplating process, however, can be very complicated. The subject is an area of chemical engineering, involving chemical reactions (both chemical and electrochemical) and unit operations (such as mixing and filtration) (1), typically referred to as electrochemical engineering. Developing feasible solutions must involve full consideration of all technical, legal, and economic implications.

STEPS IN WASTE MANAGEMENT

A successful waste management program requires using a systematic approach. One possible approach has four major steps (4). Step I involves planning and organization. The program goals must be determined and a task force organized. Step II is the assessment stage where the specific process is evaluated and is the most important step. The assessment stage can be summarized with five basic operations:

1. collecting and compiling process and waste stream information,
2. prioritizing waste streams,
3. site inspection,
4. generating options, and
5. screening options.

Once the various options have been evaluated, Step III in the waste management program is a feasibility analysis of both the technical and economic factors. Step IV is implementation of the chosen waste management program.

A successful waste management program involves a number of general techniques, the first being inventory management, which includes both inventory and materials control. Possible controls consist of hazardous chemical inventory size reduction, as well as material loss and damage reduction during handling and production. A second useful technique involves production process modifications in the form of maintenance programs, material changes, and process equipment modifications (4). The final technique of a sound waste management program is that of waste minimization and recovery. A successful management program will implement all three techniques simultaneously.

Generally, those methods involving waste minimization and recovery demonstrate some form of integrated waste treatment system (5), which tends to treat wastes at the source. A typical block diagram of an integrated waste system is illustrated in Figure 1 (5). The advantages of such a system include simplified supervision and control, reduction of waste treatment costs, simplified sludge handling, and improved rinsing. The major drawbacks include a necessity for additional process equipment and operation expense, as well as possible degradation of plating if not operated properly.

OBJECTIVES

The objectives of this study were to identify and briefly describe both existing and potential future methods of waste management for minimizing and recovering metallic wastes in the metal finishing industries, including evaluation of the advantages and disadvantages of the various methods available and being developed.

EXISTING/CONVENTIONAL METHODS

CURRENT DISPOSAL TECHNOLOGY

Chemical precipitation is currently the primary method used in the treatment of electroplating waste streams (1,5,6). The most common precipitation technique is hydroxide treatment, which involves altering the pH of a solution with sodium or calcium hydroxide to precipitate the heavy metal hydroxides. The drawbacks to hydroxide precipitation, however, include the dependence of precipitate solubility on pH and the difficult dewatering characteristics of the resulting sludge. Another chemical technique uses soluble and insoluble sulfides, with the advantages of wider acceptable pH range and much better thickening and dewatering characteristics of the metal sulfides produced. However, the major drawbacks include the presence of toxic sulfides and possible evolution of hydrogen sulfide gas in the process. The metal hydroxide sludge produced after dewatering must be fixed to prevent leaching, typically with portland cement, and then disposed of in a landfill. Future constraints on land disposal will increase the pressure to eliminate precipitation as a method of waste treatment.

MINIMIZATION TECHNIQUES

The first option one should consider to reduce wastes is minimization because it is the least expensive reduction technique and is often quite easily implemented. The cost of waste treatment depends largely upon the volumetric flow rates of waste and the concentration of pollutants in the waste water (7) areas where minimization efforts should be focused.

To reduce volumetric flow rates, modified rinsing methods should be analyzed. Since the rinse process is the primary contributor to waste streams, a countercurrent application (such as in Figure 1) may be more appropriate. For example, simply using a two-tank counter current rinse system, water usage (and subsequent waste water production) can be reduced by 99% over a single tank system (7).

The primary contributor to the quantity of waste material produced by plating operations is drag-out, which is the liquid material that adheres to the plated parts and rack when removed from the plating tank. Drag-out may be controlled and hopefully minimized by adjusting such factors as bath density and viscosity, geometry of pieces, drainage time (the most readily controlled factor), positioning of pieces, and velocity of withdrawal (5). Other options that may reduce chemical drag-out include using spray rinses or air knifes above the plating bath and reducing the bath concentration itself (7).

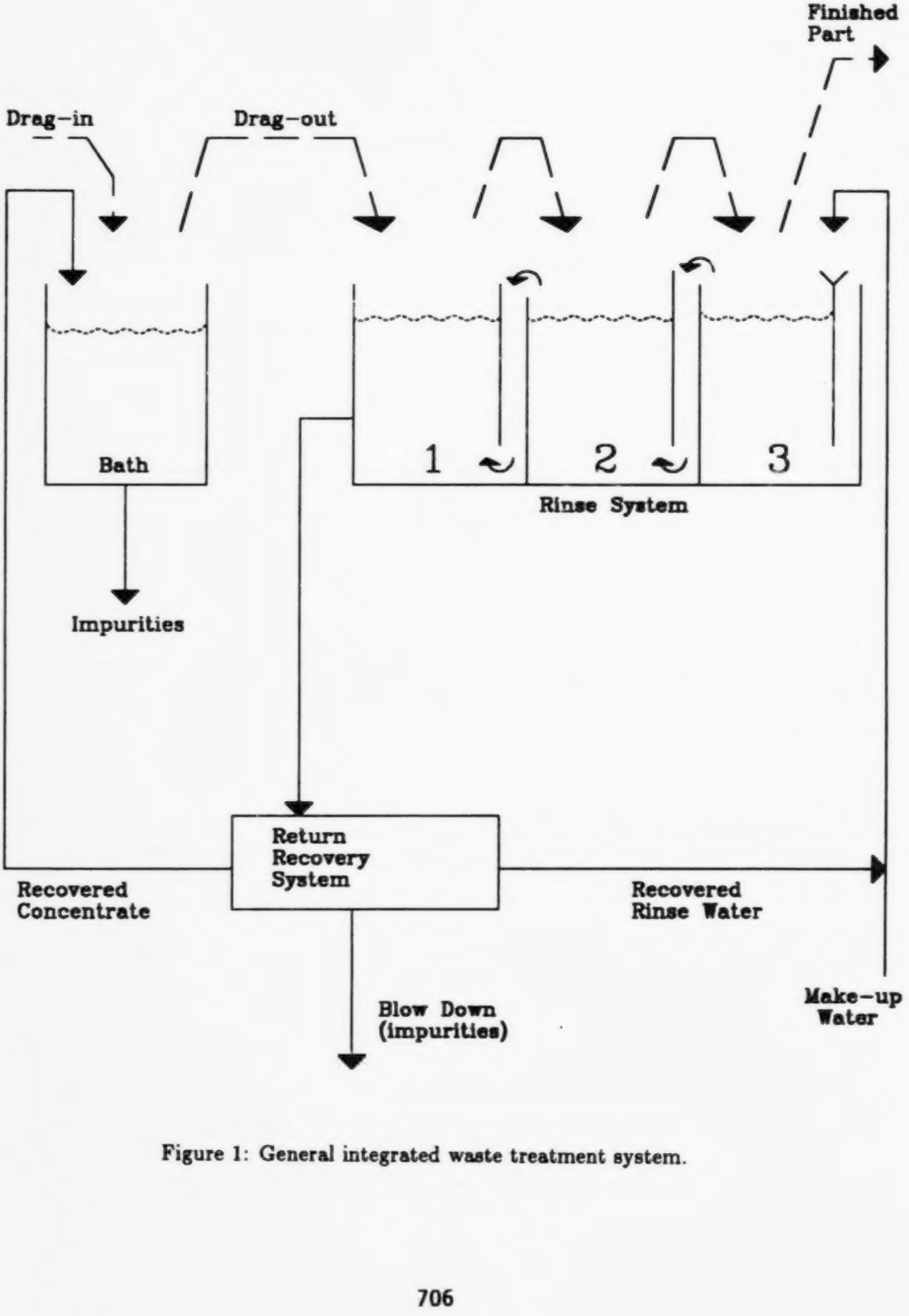

Figure 1: General integrated waste treatment system.

Other minimization options are also available. Segregation of wastes is an important technique for reducing treatment loads. When wastes are mixed, they become diluted and require larger treatment facilities for cleaning and re-separation. Also a mixture of wastes is given the hazard classification corresponding to the most dangerous material present, leading to higher disposal and liability costs. Reducing the frequency of tank dumps is another option that will lower treatment costs (5). Using less hazardous materials in the actual plating processes may also be beneficial. Other cheap and effective tools for waste minimization include using flow regulators, conductivity probes, reuse of contaminated rinses, and good housekeeping (cleaning) practices (7).

RECOVERY TECHNIQUES

When low cost plating line modifications or rinse-and-recycle modifications are not available, chemical recovery may be an option. A number of useful techniques exist for plating material recovery and range from simple evaporation to electrodialysis. With all of these methods, waste chemicals are recovered, as the name implies, and are sold or reused in some part of the process.

Evaporation is the oldest, simplest, and most durable of the recovery methods. Three evaporation techniques find common use (6) The first is atmospheric evaporation, which can use waste process heat as an energy source. The second is vacuum evaporation, which allows liquids to boil at lower temperatures, thereby preventing thermal degradation of bath additives, such as organic brighteners (7). The major problem with vacuum evaporation is the need for more sophisticated equipment and expense. The third option is a simple film evaporator.

The advantages to evaporation techniques include versatility, reliability, and recovery of nearly 100% of dissolved solids. Nevertheless, the disadvantages include a large initial investment, large energy requirements, possible need for stream pretreatment, and return of the entire stream to the plating bath (i.e., impurities are not removed, but concentrated) (5,8,9).

Ion exchange is another recovery option. Of any method, it is the best in flow rate per dollar invested, but the worst in water conservation (6). Ion exchange removes metals and impurities by using polymeric resins that replace the harmful, or valuable, ions in solution with safe, inexpensive ones. The great advantage of ion exchange is its ability to reduce the concentration of dissolved metals to very low levels; the fluid discharged from the column typically contains less than 0.5 ppm of the toxic material (10). Ion exchange works best for dilute solutions and is effective for a large number of metals (9). The major drawback is that the exchange resins, usually in the form of beads, must be regenerated by flushing with a suitable acid, caustic or brine solution, leading to added expense and downtime, as well as another stream that must be treated and/or recovered. A useful configuration of ion exchange columns involve having at least two connected in parallel to allow for continuous operation while regeneration occurs.

Reverse osmosis (RO) is a more complicated recovery method. It requires applying pressure to a concentrated solution to overcome the natural osmotic pressure and force permeation of water through a membrane (5). The concentrate may then be treated or reused and the pure permeate (water) recycled. Reverse osmosis units come in three basic configurations: spiral, tubular, and hollow fiber (5). A few drawbacks of RO include an inability to produce a sufficiently concentrated return stream and no removal of impurities (9). There may also be degradation of the membrane caused by plugging with salts or permeate compression.

Electrodialysis is a recovery method that lends itself to closed systems and is often used to reclaim metals (6). As the name implies, electrodialysis is electrolytically assisted dialysis, where an applied potential forces ions to migrate through an ion selective semi-permeable membrane. Electrodialysis is good for high drag-out rates and is also effective for concentrating rinse waters to high strength (6). The efficiency, unlike reverse osmosis, improves with increasing metal salt concentration and the only major drawback is a need for careful maintenance and operation (9).

A final recovery method that finds application is electrolytic recovery and is usually applied for drag-out tanks or spent strong solutions. It involves an electrochemical reduction of ions to elemental form onto a cathode for subsequent removal. The process requires a drag-out recovery tank, an electrolytic recovery tank (usually with stainless steel cathodes), and a recirculation pump (5). High flow rates or good agitation are also needed to circulate the bath. The major advantage is that it tends to minimize the load on the waste treatment system and pollution discharge rates while also avoiding the conversion of metal ions to sludge.

Once the metals ions have been reduced, three options for handling the metal/cathode combination exist. The metals may simply be disposed of when plated onto a cheap, plastic substrate. A high surface area cathode may also be employed where a fibrous or filamentous substrate collects the metals, which are then chemically stripped for resale. The final removal option is employed when a high purity metal extract is desired. A solid slab of high purity metal may be reduced onto a flat cathode for mechanical stripping and resale on secondary metal markets (9). The disadvantages of electrolytic recovery include problems operating with dilute solutions (low conductivity), a large electrical energy requirement, and the diffusion controlling factors (8).

FUTURE/POTENTIAL METHODS OF WASTE TREATMENT

By far, chemical precipitation has been the most popular waste treatment method, but due to the increasing costs of landfilling, new methods of hazardous waste treatment have been focusing on waste minimization. The ultimate goal is to achieve "closed-loop" operation where all raw materials entering the process line exit as part of the finished product. In this regard, conventional processes have been improved, more effective combinations of existing technologies have been developed, and new, creative technologies continue to be researched.

A problem with conventional electrodialysis processes has been fouling of the membranes. Nearly all new electrodialysis installations utilize a reversible process in which the cell polarity is periodically reversed, thereby reversing the flow to and from the concentrate and depleting chambers (11). Flow reversal tends to redissolve or physically purge precipitates and surface films, but requires membranes that can function in either the anion- or cation-selective modes, and platinum-coated titanium electrodes that can function either as cathodes or anodes.

Conventional electrolytic recovery techniques have recently evolved into fluidized bed electrochemical reactors, which has improved the economics of removal and recovery of metals from dilute solutions. (12). The typical cell consists of a set of apertured, expanded-metal-mesh electrodes immersed in a bed of small glass beads. The bed is fluidized to about twice its packed depth by pumping rinsewater upward through a distributor particle bed. The glass beads continuously scrub the surface of the electrode and promote mixing, which brings fresh solution to the electrode surface. This type of electrochemical reactor has been successfully used to recover gold, silver, cadmium, nickel, nickel-iron alloy, copper, and zinc (12).

A new variation of an older concept involves application of ultrafiltration (UF) and hyperfiltration (HF) to electroplating waste minimization and has been particularly effective for the removal of suspended solids, oil and grease, large organic molecules, and complexed heavy metals from wastewater streams (11). In UF and HF, a membrane retains materials based entirely on size, shape, and molecule flexibility. Feed solution is pumped through a membrane module and the membrane acts as a sieve to retain materials that are too large to pass through its pores. The retained materials (concentrate) then exit the module separately from the purified solvent (the permeate). The difference between UF and HF is only in its selectivity. Hyperfiltration typically removes species with a molecular weight between 100 and 500 g/mol; ultrafiltration removes species with a molecular weight greater than 500 g/mol (11).

Since individual waste minimization processes cannot always achieve the desired degree of recovery, combinations of individual processes have been developed which utilize the major advantages of the separate processes. Several examples of a combination of ion exchange and electrolytic recovery exist. Typically, the solution produced from regeneration of an ion exchange column is much more concentrated than the influent waste stream and may be ideal for further treatment by electrowinning. Electrolytic recovery converts the toxic metals in solution to their elemental form, often as metal sheets that can be reused, sold for scrap, or otherwise safely disposed. However, electrowinning is not as effective as ion exchange for reducing dissolved metals to low concentrations and, therefore, the residual solution is directed back to ion exchange for further treatment, thus creating a "closed loop" (10).

Another alternative is the re-smelting of traditional electroplating waste sludge to recover the metals, which has been implemented for reprocessing of iron, nickel and chromium-mixed sludge (13). The resulting ingots are sold to stainless steel manufacturers. The major advantage of this process is the elimination of the long-term liability associated with landfilling. However, the process is highly energy intensive and not easily applied to small scale operations with the current technology. Presently, only a few reprocessing facilities exist in the mid-Atlantic region of the U.S., leading to potentially prohibitive shipping costs.

New, creative technologies are constantly being researched. Among these is the electrodialytic ion exchange (EDIX) cell, which consists of alternate bipolar and cation permeable membranes between an anode and cathode, as shown in Figure 2 (14). The wastewater stream enters the regenerate chamber where metal and hydrogen ions migrate across the cation permeable membrane into the concentrate chamber. To balance the negative ions remaining in the regenerate chamber, water is separated into hydrogen ions and hydroxide ions by electromotive force within the bipolar membranes. The hydrogen ions replace the migrating positive ions while the hydroxide ions migrate to the anode and react to form oxygen gas and water. In the concentrate chamber the formation of hydroxide ions balance the positive ions that have migrated from the regenerate chamber through the cation permeable membrane, while the hydrogen ions formed migrate to the cathode and are reduced to form hydrogen gas. Initial process analysis of the EDIX system indicates that a single pass process is not capable of providing a water stream suitable for disposal, but does greatly reduce the metal ion concentration and could possibly be used in series and/or in conjunction with other processes to create a closed-loop process (14).

Other creative research has focused on using vermiculite and partially converted shellfish waste (15) as a medium to adsorb metal ions from solution. The ions are then recovered by eluting the medium and directing the resulting concentrated stream back to the plating bath.

New technologies are becoming more economically feasible due to the increasing costs and restrictions of current disposal methods (i.e., disposal of precipitate sludge in landfills). The trend is definitely toward closed-loop configurations, although never fully obtainable due to unavoidable contaminant build-up that can result in reduced product quality. Nevertheless, the closed-loop efforts greatly reduce the amount of sludge produced and can still pay for themselves through reduced sludge-removal costs.

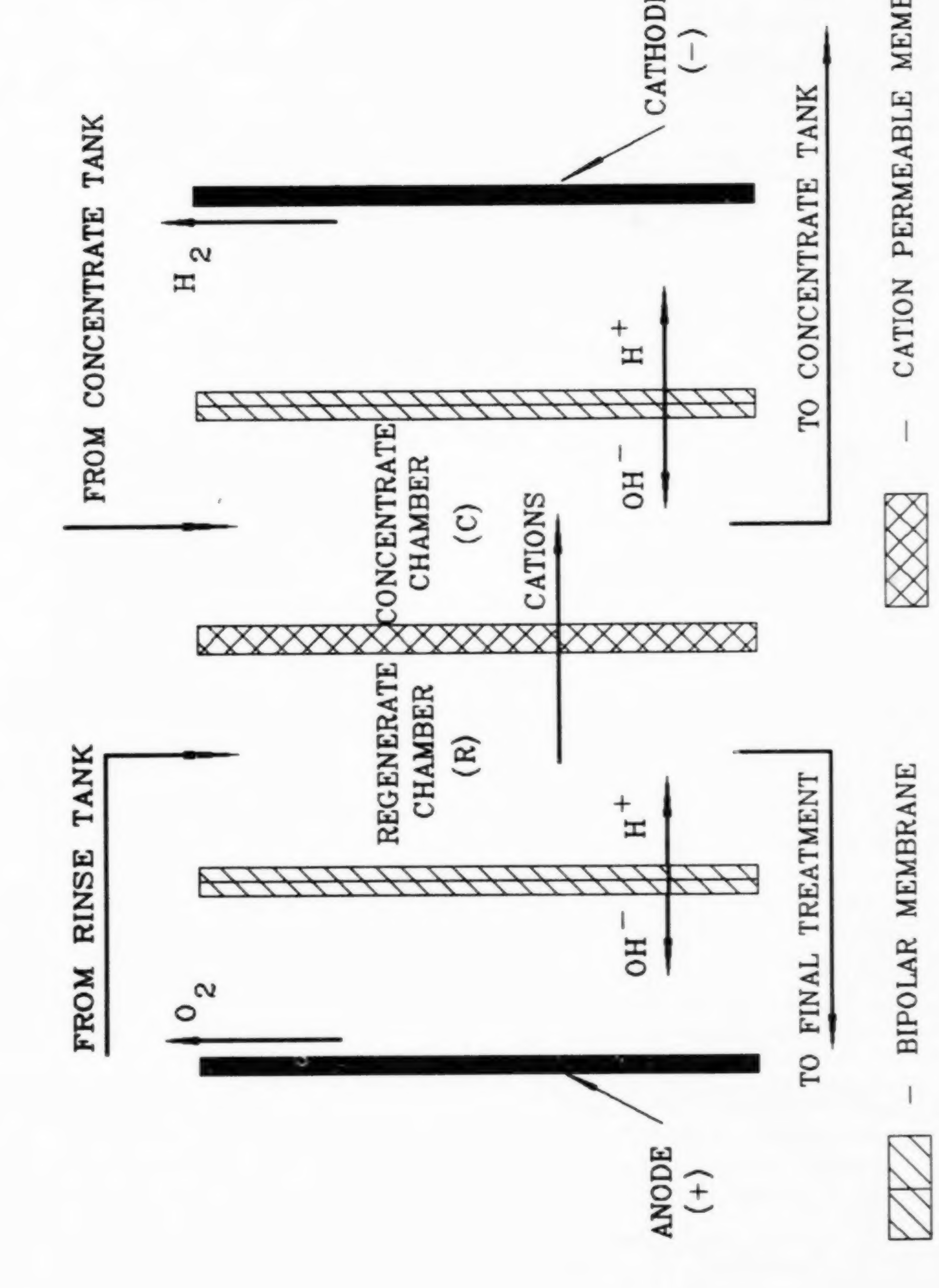

Figure 2: Schematic diagram of the electrodialytic ion exchange (EDIX) cell.

Finally, microcomputers can be utilized as a powerful tool to evaluate the performance of new and existing treatment systems (16). Programing languages, such as FORTRAN and BASIC, and spreadsheets can be used to develop mathematical models of systems to evaluate their operating feasibility without physically building prototype models and conducting laboratory experiments, thereby saving time and expense. Also, these models are convenient for evaluating existing systems, as well as developing an economic evaluation of alternatives (16). To fully utilize these tools, the electroplating industry will require increased technical expertise in the fields of chemical, electrochemical and environmental engineering.

CONCLUSIONS

1. There is a need to continue developing near closed loop processes for reuse of raw materials before they become treatable wastes, which involves emphasizing waste minimization, stream segregation, and contaminant minimization.
2. New technologies, such as in the area of electrodialysis, are being developed. They will need to be tested under actual operating conditions.
3. Computers in general, and microcomputers in particular, are a valuable, but under utilized, tool in the surface finishing industry for evaluating existing and future technologies. Training and exposure to example applications will be necessary to change this situation.

RECOMMENDATIONS

Continued development of new technologies, and combinations of them, are needed in order to approach the closed loop operation goal. To accomplish this, the surface finishing industry must be willing to support research efforts and to try new technologies as they develop. Improving waste minimization and recovery methods will also require a higher level of technical expertise in the industry to allow for proper evaluation of technical and economic options, as well as operation of these new processes. Hiring chemical engineers with environmental and electrochemical backgrounds is essential for technical/economic analysis and additional specialized training of operators.

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CFC POLLUTION:
REPAIRING THE OZONE HOLE THROUGH MUNICIPAL LEGISLATION

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From the beginning of the Industrial Revolution to the end of World War II, industrial expansion was viewed everywhere as a positive good whose environmental impacts were the price to be paid for progress. The dramatic rise in the standard of living and the decrease in mortality justified the rivers turned to industrial sewers and the SMOG-laden air.

By the 1960's the devastation in some areas was great enough to generate a legislative response at the State and Federal levels in the United States. Foaming rivers and polluted bathing beaches resulted in such regulations as California's 1969 Porter-Cologne Water Quality Control Act, and the Clean Water Act of 1972 and Safe Drinking Water Act of 1974 at the Federal level. Other States undertook the remediation of large areas lost to industrial pollution. The State of New Jersey created the Hackensack Meadowlands Development Commission to clean up the Hackensack River and its adjacent tidal lands in 1968. However, local government environmental efforts were generally limited to weed abatement, fire and building code enforcement, and refuse regulation legislation.

In 1989 the city of Irvine passed an ordinance, resulting in the regulation of the use of ozone-depleting chemicals within the city limits. As one of the 200 largest cities in the United States, and a major industrial center in Orange County, the city exerted a leadership role in acting on scientific information developed at the University of California, Irvine. Japan Prize-winner Dr. Sherwood Rowland pioneered research on the effect of chlorofluorocarbons in the stratosphere. Years of research demonstrated a clear connection between the release of CFC's and the destruction of the ozone layer that protects the Earth from ultraviolet light. Satellite photographs of the Antarctic confirmed the existence of a seasonal hole in the ozone layer of significant size. Based on the length of time that CFC's remain capable of interacting with ozone, scientists on Dr. Rowland's team predict a significant increase in the amount of ozone destruction over the next decades, even if CFC release were stopped today.

INTERNATIONAL EFFORTS TO REGULATE CFC'S

Dr. Rowland's research had come to the attention of the United States Government, and international cooperative efforts were undertaken to end the use of CFC's. The Montreal Protocol of 1987, signed by about 50 nations to date, commits the signatory nations to lowering the production of CFC's to 50 percent of the overall 1987 production by 1999. A 1989 review of the scientific data led to an agreement for a total phaseout by 2000. However, while the industrialized nations are signatories to the Montreal Protocol and its amendment, most of the developing nations are not.

LOCAL ACTION

While standards for dealing with the CFC problem can be set at the international and national level, effective implementation requires active local cooperation. Each point source of CFC emissions lies within the jurisdiction of a local or county government. Developing an implementation plan that is suitable for the entire world, or even for the whole United States, will be a lengthy process. During the developing, CFC's will continue to be released into the atmosphere. Local governments can work with the local community to effectively create local regulations that reduce CFC emissions quickly. While each municipality may release only a small portion of the world-wide total of ozone depleting compound emissions, each molecule of CFC that is recycled or destroyed is a contribution to the health of the stratospheric ozone layer. The present state of the art in recycling and product substitution is developing in response to national and international deadlines. Shorter local timelines have the effect of hastening the development of safe alternative products and processes in advance of the market pressure.

In the winter of 1988-89, the city of Irvine formed a staff committee to review the city's own uses of CFC's, including styrofoam cups for public functions, air conditioning units in city vehicles and buildings, and halon fire extinguisher systems installed in computer rooms. When it was discovered that alternative products and recycling systems were available for some applications, a program was discussed for a shift away from the purchase and use of ozone-depleting compounds.

Mayor Larry Agran encouraged the development of a larger vision of the application of this information. He reminded the staff that global improvements begin with local action. He suggested "think locally, act globally" as the theme for the development of legislation to improve the health of the stratosphere. Mayor Agran augmented the Irvine city staff committee with Council aides with past experience in environmental legislative areas. An active program to develop a city-wide ordinance to ban ozone depleting compounds was begun.

LOCAL BUSINESS RESPONSES

The local business community, contacted through the business license list, received postcard notification of the introduction of the ordinance for first reading. Each business was invited to send a representative to testify, and an extensive public hearing was held. Some businesses were concerned that their competitive edge would be lost because of the higher cost of alternative technologies. Others were concerned that customers would simply turn to other suppliers to continue to receive the formulations they desired. Council member Cameron Cosgrove pointed out that local businesses would actually develop a competitive advantage because they would be "ahead of the curve" in implementing the changes needed by the turn of the century. The implementation of the ordinance also provided a field for entrepreneurs to develop new products that would be CFC-free, with Irvine as a ready market. The major chemical companies are also moving toward CFC-substitutes in response to the international agreements. Irvine businesses would be able to convert to newer chemicals before the rush for last-minute compliance with international protocols. A local businessman, Dan Russell, stated his willingness to comply with the ordinance was based on his concern for his own children. "I want them to have a good environment," he said.

Other business community members raised concerns about the proposed legislation. Some pointed out that their activities are controlled by governmental entities, such as the Food and Drug Administration regulation of medical products manufacturing standards, and the military specifications built into contracts with the Department of Defense. Others asserted that their use of CFC's is a very small part of their manufacturing process, and the cost of retooling would be prohibitive. The higher cost of known substitutes was a concern for many of the small businesses. Product safety was a major concern within the business community, as toxicity testing on alternative chemicals has not been completed. In many cases the alternative chemicals are very new, and no testing has begun. Many alternatives are known to be more hazardous in the workplace, which is why many of the CFC applications were developed originally.

ORDINANCE REGULATING CFC USE

Following an interchange of ideas, the ordinance "Governing the Manufacture, Distribution, Sale and Recycling of Products which Utilize Ozone-Depleting Compounds" (No. 89-21) was passed by the City Council on August 22, 1989. After a section on definitions, the document includes a section outlining the specific prohibitions on the manufacture, sale, or distribution of products utilizing ozone-depleting compounds. There is a prohibition on the use of ozone-depleting compounds in new or replacement building insulation, and regulation of the disposal of ozone-depleting compounds contained in discarded building insulation. Sections regarding the use of CFC's in cooling systems include the requirement to recycle ozone-depleting compounds used as coolants in refrigeration and/or air conditioning units, restriction on the sale of ozone-depleting compounds used as coolants, and restrictions on the disposal of refrigeration or air conditioning units or systems. Other sections include a requirement for a permit to release halon to test fire extinguishing equipment, and reclamation of halons from portable fire extinguishers during servicing.

ENVIRONMENTAL PROGRAM COORDINATOR

The ordinance created the position of Environmental Program Coordinator in the City Manager's Office. The duties are to oversee the administration of the ordinance, the establishment of regulations for the implementation of the ordinance, and the enforcement of the ordinance. The coordinator is also required to provide information to businesses seeking help in obtaining alternative technologies or recycling equipment. A small library of information was developed during the subcommittee research phase that provides one basis for community information. The coordinator is required to develop an educational program to provide information to local businesses on the dangers and hazards of products made with ozone-depleting compounds. He is to establish a program to encourage the development of alternative chemicals and technologies to replace ozone-depleting compounds. Concepts developed during the ordinance draft phase included the establishment of a city-based grant program or some other incentive program to reward the development of safe alternative compounds. He is to work with other levels of government regarding the regulation of ozone-depleting compounds. There is also a provision to research the need for a technical assistance funding mechanism to assist establishments in the implementation of a recovery or recycling program for ozone-depleting compounds, or the proper destruction of ozone-depleting compounds.

SCIENCE ADVISORY COMMITTEE

Within the ordinance, a Science Advisory Committee was established as a permanent city committee to assist the coordinator with the implementation of the program. The City Manager or his designee is the chair of the committee. The creation of this committee is an acknowledgement that the business community had both significant expertise to offer and a major economic stake in the outcome of the legislative initiative. All members of the local business community were invited to attend the initial meeting and to sign up for the subcommittees.

About 50 citizens attended the first meeting of the Science Advisory Committee, with many of them selecting a subcommittee assignment. The subcommittees were designed according to the major uses of CFC's in the Irvine area. The subcommittees are Solvents, Medical Applications, Air Conditioning and Refrigeration, Halons, Military Contractors, and Foam Plastics and Insulation. The subcommittees each met individually, selected a recorder, and developed a statement regarding the anticipated impact of a CFC-ban on their portion of industry. They also undertook research projects to ascertain the available alternative technologies and recycling possibilities in their areas, and other mitigation measures that would measurably decrease the amount of CFC's released to the atmosphere. There was a consensus that while the goal is the ban of CFC's in all applications, the near-term goal is the elimination of CFC-releases to the atmosphere within a very short timeframe. Therefore, recycling and containment technologies were carefully researched for immediate application.

Each subcommittee submitted its findings to the whole Science Advisory Committee. Potential for immediate action, areas for near-term application, and future goals were recommended. Following an evaluation of this information, one representative from each subcommittee was appointed to the Exemption Committee to work with the Environmental Program Coordinator to develop an over-all exemption standard and application procedure. These standards would take into account the availability of alternative technologies and products, recycling systems, product safety/effectiveness information, and the existence of contractual limitations. The Exemption Subcommittee reviewed the information from all the subcommittees, and developed guidelines for companies seeking an exemption from the bans on CFC's imposed in the ordinance. The focus remained the immediate elimination of CFC release to the atmosphere, and the near-term elimination of the use of CFC's in manufacturing and packaging.

Since many of the members of the Science Advisory Committee are actively involved in a business that uses ozone-depleting compounds, they can offer current technical information on systems and processes that may provide beneficial alternatives to existing technology. Many of the representatives are from large firms that have the expertise to discover emerging technologies, and to evaluate them for their own use. This information may then be shared, with their permission, with other businesses seeking alternatives. For example, Cal Sonic has undertaken a major study of degreasers pursuant to purchasing an aqueous unit. The information that they developed regarding suppliers, costs/benefit considerations, and cleanliness standards will be useful to others needing similar technology. They have offered plant tours of their new equipment to other businesses. This kind of cooperation is possible only because the Science Advisory Committee provides a mechanism for the exchange of ideas and information. Since the committee members are volunteers, the cost to the city of having the committee is small.

EXEMPTIONS

The ordinance also includes provision for the granting, by the City Council, of exemptions from the regulations of the ordinance for specified periods of time. The exemption application must review the technical, practical, and economic viability of the alternatives considered, and the health, safety, and environmental impact of the alternatives. The exemption must be requested for a specified period of time, and the applicant must include information on the alternatives under consideration, and the measures that have already been undertaken to minimize or eliminate the release of ozone-depleting compounds. Since the immediate goal is elimination of the emission of CFC to the stratosphere, recycling and reclamation are critical components of an exemption application.

Several classes of exemptions were included in the body of the ordinance, recognizing either the unavailability of safe substitutes, or the imposition of a requirement for CFC use by another regulatory agency. These include Federal regulations (military contractor, FDA-regulated manufacturer), public safety considerations (the use of halon for fire fighting), refrigeration and cooling applications, licensed health care facilities, and de minimus emissions (less than 55 gallons or 450 pounds per year emitted to the atmosphere). In dealing with the exemptions based on the activities of Federal agencies, the Environmental Program Coordinator has an affirmative obligation to urge the responsible agencies to hasten the approval of substitute technologies and substitute products. Because the uses of CFC's governed by Federal regulatory agencies may continue for some time, applicants for exemptions under this section must show a good faith effort to recycle CFC products used in their processes and to minimize emissions. Although certain processes may not be changed, or certain solvents must be used, mitigation measures such as vat covers, air filters, or recycling systems can still restrict the emission of CFC's to the atmosphere.

Halon will be permitted for use in fighting fires until a safe alternative is available. However, halon may not be released in any other circumstance. All testing must be conducted using another gas. Servicing of halon fire extinguishers must include recycling and must prevent the release of any CFC to the atmosphere.

The availability of the de minimus exemption recognizes the cost-benefit issues related to retooling or changing a process where CFC is a minor component of the system. Businesses that emit only small amounts of CFC to the atmosphere may have to make a very large investment to create a small relative beneficial impact on the CFC release problem. The small user must still show a good faith effort to phase out CFC uses over time. De minimus exemptions are granted only a year at a time, and as technology improves, and costs for systems and alternative products come down, this exemption will be carefully reviewed, and possibly eliminated.

The exemption for the licensed health care facilities is also based on the small amount of CFC used for the sterilant application. While some sterilizing applications can convert to steam or heat/pressure systems, plastics and optics might be damaged by these processes. There is no safe alternative to the current CFC-ETO mixture when ETO is the sterilant of choice. Some manufacturers of sterilizers are developing recycling or reclamation systems that might be available for the small sterilizer market within the next few years.

Some companies currently using CFC's have undertaken research to eliminate the use of CFC's in the near future. In some cases the firm will request an exemption from the ordinance requirements until a specified piece of machinery can be purchased and installed. In some cases firms are undertaking testing of alternative technologies, with a specified timeline for evaluation and decision-making. These firms will submit one exemption application with a series of "milestones." As each of the milestones is reached, the firm will submit a report to the Environmental Program Coordinator. As long as the milestones are met, the exemption will remain in force. At the end of the milestones the exemption will end, because the new process or product should be in use. If difficulties are encountered that alter the original milestones, the firm must confer with the coordinator regarding an extension, or a new exemption process, depending on the nature of the difficulty. For example, if the manufacturer is delayed in delivering equipment, an extension might be arranged. If the planned process proved to be faulty and a new approach is needed, a new exemption application with new timelines would be needed.

Some firms are unable to develop an alternative to the current CFC uses. These firms will be applying for a 1 year exemption, during which time they will be required to undertake research into alternative products and technologies. The coordinator will assist them in locating possible sources of information, including trade associations, other firms using similar processes, or library materials. The fee for a "no known alternative" exemption rises each year. There is no commitment to renewing a "no known alternative" exemption after the first year. The ordinance is enforced as a California penal code misdemeanor offense.

NATIONAL IMPACT

The impact of Irvine's sweeping local ordinance was felt even during its final development stage. In July 1989, the Center for Innovative Diplomacy sponsored the North American Congress for a Stratospheric Protection Accord in Irvine. Representatives from more than 20 other jurisdictions shared their experiences in promoting environmental responsibility at the local level. Local legislators from Toronto, Canada, and Berkeley, California, shared information on the success of legislation passed in their jurisdictions. Irvine's ordinance, the most comprehensive municipal regulation of ozone-depleting compounds to date, was reviewed by the members.

Since that time action has been taken in other municipalities. The city of Newark, New Jersey, passed its own comprehensive ban on CFC's on October 4, 1990. Austin, Texas, is developing an ordinance similar to these first two. Colorado local legislators are seeking a regional approach to CFC-banning laws. Cambridge, Massachusetts, developed a comprehensive ordinance that targets businesses and universities in that city.

Other municipalities have selected portions of the ozone-depleting chemicals issue for immediate local action. Minneapolis, Topeka, and Berkeley are recycling coolant from old appliances. San Jose, Albuquerque, and Berkeley will regulate auto air conditioner emissions by requiring recycling equipment at repair shops. By initiating legislation at the local level, communities can begin to lower CFC emissions in the areas most politically acceptable to their citizenry. Rather than have no action because of industry lobbying, local legislators are able to evaluate plans for reducing CFC emissions that can be implemented with maximum public support.

Once some action has been successfully undertaken, the more comprehensive steps can come in phases. For example, in areas of the country where the weather is cold most of the year, the ban on foam building insulation might not be practical. However, recycling the coolant from auto air conditioners and from discarded refrigerators and air conditioners would not work a hardship on citizens, and would create a new industry for an enterprising local entrepreneur, while also benefitting the stratosphere. Once substitute building foam insulation materials are available, the idea of replacing and destroying the old materials as buildings are refurbished or replaced will be an easier step than an immediate ban.

LOCAL MARKETING

Local legislation also enables city leaders to market the idea of atmospheric ozone protection in a way that will most strongly appeal to the citizens. Some communities already have a strong commitment to environmental issues, so the protection of the ozone layer can be tied in to efforts to clean up rivers, lessen air pollution, or plant trees. In other communities the people are not as motivated toward environmental issues. Local legislation to lessen CFC emissions will need to be marketed there as a cost-saving measure, emphasizing the international commitment to eliminate the production of CFC's by the turn of the century. If people understand that the price of the CFC's will rise dramatically when the supply drops after 2000, they will be more interested in recycling, or finding product substitutions.

The industrial community is a crucial part of the success of a program to eliminate CFC emissions. Irvine's ordinance was developed in a committee that included business leaders. The Science Advisory Committee provided the opportunity for industry leaders to comment on the provisions during the developmental phases. By having businesses participate from the early stages, a base of industry support for the legislation was developed. The participation of business leaders also assisted city staff in better understanding the community impact of various aspects of the proposed legislation. As a result of some business concerns, there were additions to the exemption categories early in the ordinance development.

The support of large local corporations that understand the inevitable changes taking place in the world production of CFC's helped to build business community acceptance for the ordinance. Some larger firms took the initiative to investigate alternative processes and products, and presented this information at the public hearings. Having the support of the business community is important, especially in areas where many jobs are at stake in CFC-using industries. It is difficult to generate public support for legislation that may result in lost jobs for voters.

LOCAL IMPACT ON LARGER JURISDICTIONS

Community-based legislation can address local issues and concerns. It can be both responsive to community needs and environmentally responsible. Regional cooperation offers the possibility of developing packages of local legislation that address concerns that cross political boundaries. The regional approach may be especially important for smaller communities that would need to cooperate to develop economically viable recycling or disposal facilities. Comprehensive State and Federal legislation may be more difficult to develop because of competing interest groups. Local and regional legislation can point the way for State and Federal laws by developing a series of regulations based on local consensus. State-wide legislation can be based on those activities found to be acceptable to most communities.

Community-based legislation may also have an effect on Federal agencies. Once many jurisdictions have shown their interest in alternative technologies and product replacements for CFC applications, the regulatory agencies may be more encouraged to proceed with safety and toxicity testing. The FDA is not reviewing alternative sterilizing methods at the present time, for example. Perhaps if more jurisdictions were encouraging the use of alternative technologies these investigations would become a higher priority with the FDA. Also, local legislators could work with their Federal representatives to develop funding for the FDA and other agencies needing to undertake expensive testing programs for alternative products. If representatives from several States shared a common concern for product testing, Federal legislation to pay for the product testing might be easier to pass.

CONCLUSION

Irvine's ordinance to regulate the emission of ozone-depleting compounds is a model for other municipalities concerned about the environment. Municipal action has the potential to directly affect emissions to the atmosphere. Regional cooperation can broaden the benefits of local action, and make some activities economically feasible through economy of scale. Municipal and regional actions provide a pattern of legislative consensus that State and Federal legislators can support. Local action sends a signal to Federal regulatory agencies that there is a need for testing of alternative technologies. The combined efforts of municipalities across the United States can indeed have a global impact, resulting in a significant reduction of CFC's emitted to the atmosphere.

Now is the time to repair the ozone hole through municipal legislation.

A NOVEL LOW-POLLUTION APPROACH FOR THE MANUFACTURE OF BLEACHED HARDWOOD PULP

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ABSTRACT

Kraft pulp is the reference chemical pulp in the wood pulp and paper industry. The traditional kraft pulping process offers versatility in using virtually any type of lignocellulosic raw material,and production of physically strong pulp. Unfortunately,the kraft pulping yield (from raw material) is low,and the resulting pulp is difficult to bleach. Air emission from kraft pulp mills is extremely odoriferous. Chlorine and chlorine-based compounds are the conventional reagents used to achieve high pulp brightness and physical strengths,at a relatively low costs. Bleaching with chlorine also produces considerable amount of deleterious chlorinated substances in the process effluent and in the finished pulp.

The present research work at Arbokem Inc. (Canada) has focused on the development of an improved means to manufacture high quality chemical pulp without the use of chlorine or chlorine dioxide in the bleaching steps.

The technology is centred on the use of neutral sulphite pulping with the aid of 9,10-anthraquinone (NSAQ Process). Either sodium or potassium base may be used. Typically the unbleached aspen (Populous tremuloides) pulp has a brightness in the range of 65 to 70 points. In contrast,unbleached kraft pulp has a brightness of less than 35 points. The NSAQ Process typically provides 5 to 10% points higher yield than that of the traditional kraft process. Thus,NSAQ pulp requires considerable less intensive bleaching than kraft pulp. Our laboratory test results showed that high brightness pulp (>86%) can be readily achieved with the use of only oxygen and hydrogen peroxide as bleaching reagents. No chlorine or chlorine dioxide is required. The resulting pulp strength and optical properties are comparable to those of bleached kraft pulp.

Because only oxygen and hydrogen peroxide are used as the bleaching reagents,the bleaching effluent may be recycled,for use within the manufacturing process,to a very substantial degree. Even if no bleaching effluent is recycled to the pulping chemical system,the pollution loading of the raw untreated bleaching effluent is forecasted to be less than 3 kg BOD/MT pulp,and less than 3 kg Pt-Co colour/MT pulp.

INTRODUCTION

Conventional sulphite pulp is generally recognized to have lower physical strengths than kraft pulp. In the early 1970's, sulphite pulping in the alkaline regime was discovered to provide a pulp with similar quality as that of conventional kraft pulping [1]. This new sulphite pulping technique was noted to give higher-yield and easily-bleachable pulp. A small sulphite pulp mill might be less expensive to construct and operate than a similar-size conventional kraft mill.

The alkaline sulphite pulping approach was never commercialized because its delignification rate is nearly 5 times slower than that of a kraft process. Fortuitously,the addition of anthraquinone-type (AQ) catalyst was found to be very effective in accelerating the sulphite delignification rate [1,2]. In practice,AQ addition has been generally observed to be much more effective for the alkaline sulphite process than for the kraft process [3]. The use of the sulphite-AQ process to make a very high linerboard has gained considerable interest in the USA and elsewhere during the past few years [4-7]. Typically,the yield advantage over "high yield" kraft pulp is 15 to 25%,based on oven-dry wood.

As given by its name,neutral sulphite-anthraquinone (NSAQ) pulp is made by sulphite pulping of hardwood (or softwood) chips under mild alkaline conditions. Anthraquinone (AQ) is added as a pulping catalyst. Anthraquinone has been approved for used as a catalyst in pulping by the U.S. Food and Drugs Administration [8] since 1980.

Most of the deciduous forest in Canada and northern United States is aspen (Populus tremuloides). In Wisconsin and Minnesota,aspen sulphite and mechanical (groundwood) pulps have been used in integrated paper mills for more than 50 years. During the past 5 years,aspen has been gaining rapid acceptance as an excellent wood furnish for the production of premium-grade market kraft pulp and BCTMP [9,10].

The purpose of this work was to develop a process for the production of market-type bleached aspen pulp based on the NSAQ pulping,and bleaching without the use of chlorine-based chemicals.

EXPERIMENTAL

Canadian aspen wood (Populus tremuloides) was sampled from deciduous forests in Quebec and Alberta provinces. A small amount of black poplar (Populus balsamifera) was also included in the wood furnish of several test runs. In all cases,wood chips were used within 3 months of the felling.

Laboratory pulping and effluent tests were conducted at the Arbokem laboratory in Montreal. Additional pulping tests were performed under contracts from Arbokem at the laboratories of Econotech Ltd. (New Westminster,Canada),Universite du Quebec (Trois Rivieres,Canada),and Lakehead University (Thunder Bay, Canada).

Both one-litre "bomb" and 10-litre (with liquor-recirculation) batch digesters were used. Oxygen bleaching was carried out in a stirred autoclave. Peroxide bleaching was conducted using conventional laboratory-bag techniques. Pulp testing was made with TAPPI and CPPA Technical Section Test Methods.

RESULTS AND DISCUSSION

Unbleached Pulp

Previous work on Canadian aspen (Populus tremuloides) has suggested that aspen is probably the most suitable hardwoods for use with the NSAQ pulping process [11,12]. Unlike Canadian maple (Acer spp.) and birch (Betula spp.),aspen can be readily pulped with the NSAQ technique [13]. Table I shows the results of several pulping tests made with some representative NSAQ cooking conditions with different chip samples. The aspen NSAQ pulps normally had an unbleached brightness in the range of 58 to 69 points,and pulping yields between 62 and 65%. In contrast,aspen kraft pulp normally has a brightness of only about 35 pts and a total (unbleached) pulp yield of about 55%.

Unlike the kraft cooking method,the NSAQ pulping process offers a very wide range of operating conditions (including time,temperature and chemical charge) to produce virtually any desired grades of pulp. For example,the ratio of sulphite to alkali may be adjusted for the production of a softwood pulp with kraft-like strength [14,15].

As given in Figure 1,the tear-tensile strength relationship of NSAQ aspen pulp is compared favourably against that of the example aspen kraft pulp.

Bleached Pulp

NSAQ aspen can be bleached readily to high brightness. In order to fully utilized the high-brightness of the unbleached pulp,aspen NSAQ is best pre-bleached with oxygen. Kovasin et al. [16] has reported that oxygen pre-bleaching is ideally suited for the processing of NSAQ softwood pulp. Conventional bleaching such as CEDED is not the most appropriate approach.

Moreover,with continuing increased emphasis on the presence of chlorinated organics in finished pulp and in effluent,it is prudent to use non-chlorine based bleaching chemicals,whenever possible.

Kappa number of unbleached NSAQ aspen does not offer the same guideline on bleachability as that of kraft pulps. The residual lignin is believed to be different in unbleached NSAQ and kraft pulps [12].

As shown in Table II,a sequence such as OPP or O_pP could be used to produce high-brightness "chlorinated-organics free" aspen pulp with high viscosity. The brightness stability of peroxide-bleached pulp is good. For example,the brightness of OPP-bleached pulp (Sample B31,Table II) decreased from 85.3 pts to 83.5 pts,in a year storage at room temperature.

The oxygen-peroxide bleached pulps had high bleaching yields. Typically,the bleaching yield in the peroxide stage is 100%.

In comparison,a kraft aspen pulp,with comparable unbleached Kappa number,would be extremely difficult to achieve this brightness level in such two stages of bleaching.

Figure 2 shows that OPP-bleached NSAQ aspen pulp has good strength properties of papermaking.

Effluent

Because no chlorine or chlorine dioxide is used in bleaching, there would no involuntary production of dioxins,furans and other chlorinated organics in this type of pulp mill.

The oxygen pre-bleaching effluent is proposed to be routinely recycled to the pulping chemical system.

As shown in Table II,we have found that Na_2SiO_3 may be replaced by commercial DTMPA (diethylene-triamine-methylene-phosphonic acid) or DTPA (diethylene-triamine-pentaacetic acid) peroxide stabilizers,with little or no adverse effects on achievable bleached pulp brightness [17].

With the displacement of silicate, the possibility is now opened to recycle a substantial amount of P-stage bleaching effluent to the pulping liquor system. There would be no chlorine-related chemicals in the OPP bleaching effluent.

In the OPP sequence, the estimated discharge of COD would be about 10 kg/ADMT pulp, if no P_1 and P_2 effluents are recycled to the pulping liquor system. The corresponding BOD discharge of untreated combined P-stage effluent would be less than 4 kg/ADMT pulp.

From our laboratory test data, the discharge of colour in the combined P-stage effluent has been forecasted to be less than 3 kg/ADMT pulp. In comparison, a modern "OCED-bleached" hardwood kraft mill would have a colour emission of the order of 20-30 kg/ADMT pulp [18].

With such low levels of BOD and COD in the bleaching effluent, it is expected that the raw P-stage bleaching effluent would have a very low degree of toxicity to fish.

Because the spent sulphite pulping liquor is alkaline, the evaporator condensate would have a low BOD loading. From our lab-scale liquor evaporation experiments, we have estimated the BOD loading to be about 6 kg/ADMT pulp.

The excellent quality of the raw effluent (bleachery + evaporator condensate) would provide an opportunity for the extensive recycle of this effluent (after conventional biological treatment to reduce BOD and COD) for re-use within the manufacturing process.

Commercial Development

The aspen NSAQ technology is ready for commercial practice. Digester operation is relatively simple. The entire fibre and liquor lines could be based on existing commercial process equipment. There are NSAQ pulp mills (softwood for bleachable grades, and hardwood for packaging grades) in commercial operation in Finland, Japan and New Zealand for nearly 8 years [19-21].

Established sulphite recovery systems, such as a standard recovery boiler followed with a Tampella TRP or Stora chemical conversion unit, may be used safely and efficiently. Unlike the kraft process, the emission of odoriferous reduced sulphur compounds from the burning of spent NSAQ liquor would be several orders of magnitude lower.

Because NSAQ aspen pulping is a low-alkalinity approach, separate lime kiln and causticization unit operations would not be required. In fact,soda ash instead of caustic soda may be used as the pulping chemical make-up.

CONCLUSIONS

The neutral sulphite-anthraquinone (NSAQ) pulping process was investigated as a means to produce an economical aspen market pulp. Canadian aspen (Populus tremuloides) can be cooked and bleached readily. This excellent response to NSAQ processing is perhaps unique among the common temperate zone hardwoods.

The major findings of the present study were:

1. Unusually high yield of 60 to 65% (for a full chemical pulp) can be obtained.

2. Unbleached pulp has a very high brightness,up to 70 pts.

3. Unbleached pulp is easily bleachable,using the OPP or O_pP sequence,to achieve 85 to 90 pts brightness.

4. Oxygen/peroxide bleaching would not result in any residual chlorinated organics present in the finished pulp or in the effluent.

   This bleaching approach opens the possibility of substantial recycle of the bleachery effluent into the pulping liquor system.

5. If recycle of the P-stage effluents was not practiced,the discharges of BOD and colour in the raw effluent would be less than 4 kg/ADMT pulp and less than 3 kg/ADMT pulp, respectively.

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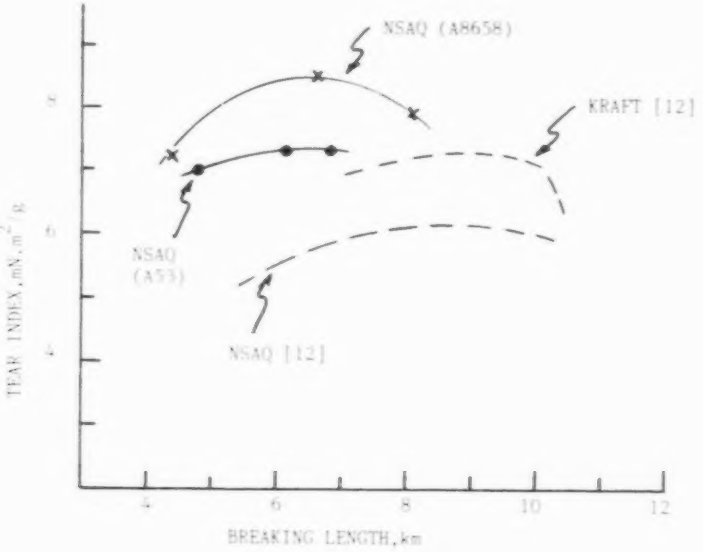

Figure 1 - Tear-Tensile Strengths of Unbleached Aspen NSAQ and Kraft Pulps

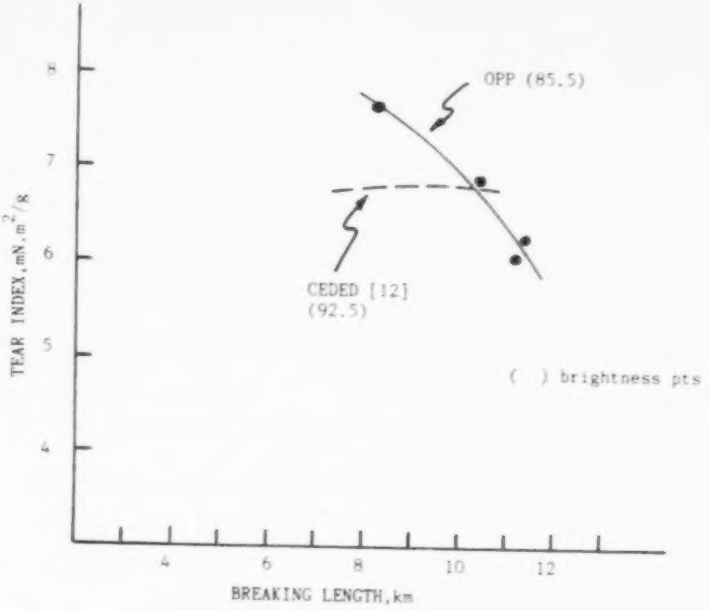

Figure 2- Tear-Tensile Strengths of Bleached Aspen NSAQ Pulp

Table I - Representative NSAQ Pulping Tests

Test Run	A53	A41	A884A	A1615N
Wood furnish				
Aspen,%	100	100	90	100
Balsam poplar,%	0	0	10	0
Total Na_2O charge, % on o.d. wood	18	18	18	18
Sulphite/Total Na_2O	0.85	0.85	0.85	0.85
AQ,% on o.d. wood	0.1	0.1	0.1	0.1
Liquor/wood ratio	4.0	4.0	4.0	3.5
Time to max. temp.,min.	125	125	125	120
Maximum temp.,deg. C.	175	175	175	165
Time at max. temp.,min.	90	120	90	300
Total pulp yield,%	65.1	64.6	64.7	62.0
Rejects,%	1.25	0.7	3.5	0.8
Kappa number (scr.)	26.3	24.0	21.6	16.7
Viscosity,mPa.s	51.3	53.3	NT	68.9
Brightness,unbl.,pts	63.7	58.2	69.4	NT

NT = not tested

Table II - Bleaching of Selected Aspen NSAQ Pulps

Test Run No.	B1615N	A884A	B31	A884B
Kappa number	16.7	21.6	15.7	29.0
Bleaching Sequence	OP	OPP	OPP	O_pP
First Stage				
Oxygen pressure,psig	80	60*	60*	60*
H_2O_2,%	--	--	--	2.0
NaOH,%	2.1	1.5	2.0	1.5
$MgSO_4.7H_2O$,%	0.5	--	--	0.5
DTMPA,%	--	--	0.25	--
Time,min.	30	30	30	50
Temp.,deg. C.	92	90	110	110
Consistency,%	12	12	12	12
Kappa number	9.8	NT	5.0	NT
Brightness,pts	63.8	NT	72.3	87.0
Viscosity,mPa.s	35.1	NT	38.1	NT
Second Stage				
H_2O_2,%	3.0	1.5	0.5	1.0
NaOH,%	1.7	1.4	1.0	1.5
Na_2SiO_3,%	3.5	5.0	--	5.0
$MgSO_4.7H_2O$,%	--	--	0.5	0.5
DTMPA,%	--	--	0.15	--
Time,min.	330	120	120	120
Temp.,deg. C.	60	75	75	75
Consistency,%	10	14	12	14
Brightness,pts	79.5	84.8	82.6	90.5
Viscosity,mPa.s	NT	NT	34.5	NT
Third Stage				
H_2O_2,%	--	1.0	1.5	--
NaOH,%	--	1.4	3.0	--
Na_2SiO_3,%	--	5.0	--	--
DTMPTA,%	--	--	0.35	--
Time,min.	--	120	120	--
Temp.,deg. C.	--	75	75	--
Consistency,%	--	14	12	--
Brightness,pts	--	86.3	85.3	--
Viscosity,mPa.s	--	NT	29.3	--

Note:
1. All chemical charges are based on o.d. pulp
2. NT = not tested
* Estimated

TOWARDS THE PROMOTION AND IMPLEMENTATION OF POLLUTION PREVENTION AND CLEAN TECHNOLOGY IN DEVELOPING COUNTRIES: THE CASE OF GHANA

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ABSTRACT

This paper gives a brief account of the problems associates with industrial development and its attendant pollution impacts in a developing country, Ghana.

It examines efforts so far made in preventing pollution and looks at various policy options and strategies for the promulgation, propagation and promotion of clean technologies within the broad context of sustainable development. It is hoped that these options and strategies coulld be applied, with modifications, in most developing especially African countries.

1.0 INTRODUCTION

The problems of underdevelopment are well-known. However, the issues involved in the development of natural resources for inudstrialization and economic development of poor or developing nations are diverse and complex that in most cases, easy solutions elude policy makers and implementors.

Socioeconomic issues like provision of adequate food and water supply, clothing, housing, health care, education, poverty and squalor and high population growth confront many of these countries.
In trying to resolve these issues, these countries adopt measures and policies which lead to high external trade deficits, high inflationary rates and overexploitation of natural resources.

Efforts at industrialization raise in their wake the importation of raw materials, machinery and technologies, some of which may be obsolete and/or environmentally unfriendly, improper resource allocation and utilization, shortage of skilled manpower, liquidity problems, underutilization of installed capacity and pollution of the ecosystem.

Besides, some of these countries in the third world are forced or cajoled into accepting toxic wastes to be dumped on their land, where there are no facilities to treat them, to the detriment of the peoples' health and ecosystem

The need therefore for developing countries to look at industrial development in the overall context of environmentally sustainable national development, incorporating pollution prevention measures and policies, is imperative.

2.0 CLEAN TECHNOLOGY - SUSTAINABLE DEVELOPMENT: RELATIONSHIP

2.1 Clean Technologies (CT)

Clean technologies may involve any of the following:
- product redesign or reformulation
- process modification
- technological innovation
- raw material substitution
- recycling and reuse of wastes.

Hence it is clear that clean technologies have several advantages over conventional technologies, including:

- Source reductionof wastes and pollutants
- resource generation
- waste minimization
- risk and hazard reduction

2.2 Substainable Development (S.D)

Sustainable national development envisages:

- adequate food supply and food security
- adequate and treated water supply
- provision of abundant energy
- conservation of natural resources including game and wildlife, forests, land, etc.
- adequate clothing and shelter
- primary health care and disease education
- protection of the overall environment

2.3 CT-SD Relationships

The common factor between these two parameters in the environment. The environmental challenge of this decade, therefore, as optly describe by the theme of this Conference is Pollution Prevention: Clean Technologies and Clean Products for Sustainable Industrial Development. Clean technologies will promote primary health care, optimal resource management and better living conditions.

3.0 CLEAN TECHNOLOGY AND POLLUTION PREVENTION STRATEGY

3.1 Policy Direction and Options

In view of the desired growth in industrial activities in developing countries and the Government's determination to increase industrial output through structural reforms, increased private sector development and investments, etc, it is expedient to examine options for Industrial Pollution Prevention and Clean Technologies with a view of finding alternatives for undertaking environnentally-sound sustainable industrial development.

These could include technical, managerial, legislative and policy options. [1]

3.1.1 Technical Options

- Introduction and enforcement of sound hazardous waste disposal methods (viz, labelling, storage, transportation, handling, treatment, and final disposal). This may be very expensive for most industries.
- Acquisition and transfer of clean technological processes that limit the amount of by-products and wastes. This may involve the acquisition, not only of machinery but also new raw materials-could be expensive.
- Recycling and utilization of by-products and wastes for the manufacture of secondary raw materials of less stringent quality. This is environmentally cost-effective.
- Identification and characterization of hazardous pollutants and their control in industry.
- Standard setting, monitoring and evaluation of impact parameters (source, persistence, toxicity, bioaccumlation, etc).

3.1.2 Managerial Options:

These could include the incorporation of environmental protection, workers' health and safety as well as hazard mitigation measures into Companies' management and workers' training programme.

- Provision of resources by top-management for the planning, implementation and monitoring of preventive environmental programmes.
- Cooperation between Ministries and institutions that deal with industry, health and environment in formulating and implementing long-term action programmes on Risk Management and Pollution Control.

3.1.3 Legislative Options

- Institution of penalties for environmental pollution (above standard tolerance levels) in industries.
- Enactment of an Environmental Impact Assessment Legislation/Decree for compliance by present and future industries.
- Institutional strengthening of Sanitation and Occupational Health Enforcement Agencies.
- Provision of legislative backing for the Environmental Protection Council.

3.1.4 Policy Options

- Formulation of Industrial, Science and Technology Policy
- Formulation of an Environmental Action Plan to facilitate environmentally sustainable economic development in the Country.
- Introduction and incorporation of an Environmental Impact Assessment Policy and procedures in all aspects of industrial establishment (selection, sitting operation and monitoring) in the country.
- Establishment of emergency planning and response programme for risk assessment, hazard identification and preventive risk management in industries.
- Establishment of an Industrial Pollution and Waste Management Center or laboratories to undertake base-line data acquisition,, surveys, emission level monitoring and evaluation, environmental standards setting, industrial pollution, risk and hazard management and industrial consultancy on waste management technologies.
- Establishment of Regional Cooperation in Pollution Prevention and Clean Technology through Regional Networks.

3.2 Key Directions to Pollution Prevention

A 5-step direction is proposed for Pollution Prevention and Clean Technology in developing countries. [2]

1. Prevent Generation
2. Recycle and Reuse
3. Treat and Control
4. Minimize Exposure
5. Educate and Train

3.3 Objectives and Mode of Implementation

3.3.1 Prevent Waste Generation

- Evolve mechanism for the development or acquisition of environmentally benign technologies, processes and products in all sectors of the economy.

- Establish a system of regulations and laws to ensure EIA and standards compliance in trade, commerce and industry.

- Educate industries, entrepreneurs and population on use and abuse of the environment, waste minimization and source reduction, technology and non-technological approaches to pollution prevention and clean technologies.

3.3.2 Recycling and Reuse

- Assessment of industriul, agricultural and municipal wastes-types and quantities and their recycling potential.

- Assessment of existing technologies and possibilities of adapting clean technologies waste reduction, and recycling techniques.

- Techno-Economic and marketability assessment

- Conduct of R&D studies in the areas of product, process, socio-economic, and anticipatory research in recycling and reuse.

- Pilot plant studies and technology transfer and adoptation.

- Promotion and propagation of reusability and recyclability as well as demands for recycled materials.

3.3.3 Treatment and Control

- Treatability Evaluation

- Hazardous Waste Management Research and Development

- Application of cost-effective and best-demonstrated available technology (CEBDAT) for Treatment and Disposal of Waste. Waste Reduction Innovative Technology Evaluation (WRITE)

3.3.4 Minimization of Exposure

- Site inspection and waste stream identification

- Performance evaluation of disposal sites, treatment facilities, and recycling technologies

3.3.5 Education and Training

Current awareness programmes, formal and informal education and training programs on the following:

- Industrial Safety and Occupational Health
- Resource Conservation, Recovery and Management
- Environmental Pollution Control
- Risk and Hazardous Wastes (nature and impacts on man and the environment)
- Research in Clean technologies and Clean Products

4.0 THE CASE OF GHANA

4.1.0 Country Profile

4.1.1 Geographical

Ghana lies on the coast of the Atlantic Ocean along the Gulf of Guinea (W.A). between lat. 4o 50' N and 6 o (550 km), border-Togo, Cote d'Ivoire and Burkina Faso, It has 10 regions, 110 districts and 47,800 communities.

4.1.2 Demographic

The current population of Ghana is 14 million with a rate of population growth 2.6%, MMR 10.2/1000, IMR - 90/1000, life expectancy is 56 years, whilst maternal and infant mortality rates are 10.2 and 90 per 1000 respectively.

4.1.3 Industrial

There are about 4,073 industries in about 10 sectors. 2,098 of these are small scale industries whilst 1975 are classified as medium-to-large scale. There has been a two-fold increase in the number of industries since 1979, 67.7% of which are situated in the Greater Accra Region alone. Most of these are now operative around 30% of installed capacity. [1]

4.2.0 Problems Facing Industries

The problem areas confronting the Ghanian industrial sector are:

> Expertise, raw material acquisition, finance and tax structure choice and upgrading of technology, QC, spare parts, and external competition and quality control, as well as environmental pollution control, waste management, risk, hazard and emergency response management.

4.3.0 Status of Environment

4.3.1 Air pollution

1. Mining areas: Arsenic Pollution is prevalent in the mining areas as show below: [3,4]

	PRESTEA.	OBUASI	WHO LIMIT
Foodstuff	6,000 ppm	0.65-14.75 ppm	1.00 ppm
Vegetation	360 ppm	4,700 ppm	--
Water	2-6 ppm	1.40 ppm	0.05 ppm
Soil	70.48 ppm	147.5 ppm	--
Hair	540 ppm	77-1940 ppm	0.03 ppm

2. This has been related to the "black spot" skin cancer in the areas. VALCO also discharges fluoride-laden fumes from its aluminum smelter

3. Oil Refinery at Tema emits hydrocarbon fumes into the atmosphere in and around Tema.

4.3.2 Water Pollution

Analysis of water from the Ankobra River near Restea shows up to 10-64 ppm of cyanide. Heavy metal pollution, specific organics, dyes, paints, pigments and grease together with very low BOD (0-06 - 0.9 mg/l) and DO (0.8-3.5 mg/l) values characterise the Odan River, Kovle Lagoon and water bodies around the Volta Basin.

4.3.3 Solid Wastes

These include solid wastes from the following industries:

4.3.3.1 Mining Industries

Gold, bauxite, manganese and ore-beneficiation industries. Wastes incllude gold tailings, sludge, scrap metals and equipment, etc. [5]

4.3.3.2 Chemical Industries

These include the following industries: Chlor-alkali, salt, surface, coating, food, glass, pharamaceutical, oils, fats, soaps and detergents, fermetation, and other chemical processing industries. A conglomerate of hazardous and toxic wastes are generated, that could be very imicable to human health and safety.

4.3.3.3 Other Industries

Other industries like the metal and metallurgical, textile, plastics, paper and printing, food processing, agro-based, construction and petroleum industries also generate a lot of solid wastes. For example, about 377,000 tons of scrap has been estimated in Ghana [6] and about 8,500 tons of waste plastics per year in Accra-Tema. [7] The main oil refinery GHAIP at Tema distributes petroleum products to thousands of filling stations that service maintenance workshops throughout the country. A great deal of used lubricants with high lead levels are discharged into the ecosystem.

4.3.4 Noise and Vibration

Through this source of pollution has not been given all the necessary attention in Ghana its impact on the workers in manufacturing and construction industries is quite high.

4.4 INDUSTRIAL POLLUTION MANAGEMENT IN GHANA

4.4.1 Experience in Pollution Management in Ghanaian Industries

The Mining Sector is guided by a set of environmental regulations under the guidance of the Mines Department. However, emission levels and environmental standards have to be set to make the regulations effective.

Most of the manufacturing industries in Ghana have no facilities for waste-water treatment, neither do they have monitoring devices for air and water emissions. Besides, effective waste management in these industries are virtually absent.

Dumping and open burning are the main methods of waste disposal and treatment. These are not cost-beneficial, neither are they environmentally sound.

4.4.2 EPC

The Environmental Protection Council set up by the Government of Ghana has, so far been carrying out programmes of education campaigns without a legislative backing. It uses facilities from the CSIR to carry out laboratory work. Hence in the absence of legislative instruments, EIA policy, laboratory facilities and well-trained environmental scientists, the EPC is unable to do the monitoring, standard setting, risk assessment and industrial pollution-cum-waste management.

4.4.3 Research Institutions

Some CSIR institutes, notably Institute of Aquatic Biology and Water Resources Research Institute have monitored mainly water effluents. The Industrial Research Institute of the CSIR has, in the past two years, undertaken a project on Recycling, Utilization, Quality Control and Environmental Pollution Control of Industrial Wastes. The first phase of this project involved current awareness programme and data collection through a survey of over 74 industries, [1] and confirmed the fears that industrial pollution might assume alarming proportions very soon, if mitigation steps are not taken as soon as possible.

4.4.4 The Factory Inspectorate

This organ works under the auspices of the Ministry of Labor and Social Welfare. It conducts on-site insp[ection of factories to assess internal pollution, occupational safety and hazard mitigation measures. It seems, however, that there is the need to coordinate its activities with those of the Environmental Protection Council and the Industrial Research Institute for an effective implementation of its perforamnce. The lack of testing laboratories make this even more urgent.

4.4.5 The Government's Environmental Action Plan (EAP)

The Government set up a National think tank on Environmental Issues in March 1988, to draw up a working programme of action on the environment to be embodied in its second Structural Adjustment Programme. The group was charged with the responsibility of addressing issues on the environment pertaining to deforestation, desertification, soil degradation, exploitation of natural resources and environmental control. IRI was nominated to serve on the Think Tank.

The group identified key issues, missing information areas for further study and research, policies to be implemented and made appropriate recommendations to Government for the planning, implementation, monitoring, and coordination of environmental programmes in Ghana.

Further to the work of the Think Tank, the Government set up working groups to prepare an Environmental Action Plan (EAP) on the issues of Land Management, Forestry and Wildlife, Water Management, Marine and Coastal Ecosystems, Mining, Industry and Hazardous Chemicals.

The EAP is to define a set of policy actions, related investments and institutional strengthening activities to make Ghana's development strategy more environmentally sustainable.

A proposal for the setting up of an Industrial waste Management Research Laboratory under IRI was submitted to government by the Industrial Research Institute. The EPC is also being assisted by UNEP/IEO to draw up an Industrial Environmental Policy. Conferences, seminars and workshops are being organized to coordinate all sectorial work being done in the country.

4.5 Linkages

Whilst efforts are being made to increase internal linkages, cooperation and coordination between all organizations and institutions involved in the work of the environment, institutional and governmental linkages with various international organizations like the UN is also given priority attention. UNIDOs assistance to Ghana is setting up the Industrial Pollution on Waste Management Research Unit is very much desired, its assistance in training Ghanaian personnel is also appreciated. UNEP, FAO and WHO have also contributed in no small measure.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Though the number of industries in Ghana is small, nonethless identifiable impacts on the environment has been substantial. Taking cognisance of the fact that most technologies imported into the country did not incorporate environmental considerations and/or pollution prevention/mitigation measures, it has become very imperative to take remedial steps to curtail the degree of environmental pollution, especially in the areas of mining, chemical and textile sectors.

Government's concern has been backed up by concrete actions to enhance environmentally sustainable development in Ghana. Hence, Ghana's experiences as well as the various options outlined in this paper can serve as guidelines or examples for other struggling developing countries.

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Clean Technologies and Clean Products

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HAZARDOUS WASTE MINIMIZATION: MAKING IT HAPPEN

by

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ABSTRACT

This paper:

- describes problems and success stories relative to implementation of hazardous material (HM) management and hazardous waste (HW) minimization programs in a large, diverse organization, specifically the U.S. Navy.
- describes how the Navy defined the HW problem, established RDT&E goals, assessed current technologies, and implemented both HM control and HW minimization programs.
- highlights unique shipboard problems and progress in reducing HM use.
- discusses program goals, first year results, and future plans.
- attempts to project progress 5 years from now and outline barriers to success.

PRESENTATION

Pervasive and long-lasting changes that will affect our way of life are occurring in the area of hazardous materials (HM) and hazardous waste (HW) management. Compared to the way we did business 20 years ago, a revolution is underway. These changes are in various stages in almost every size industry, business, and government organization. Eventually, it will even invade our private lives and change our household habits.

One could characterize the 60s and 70s, at least in the U.S., as a period of free love, a declining human birth rate, and reduced acceptance of responsibility by individuals. The 80s look like a turning point. Can we predict what will be said about the next two decades? We're certainly entering an age of more caution: cautious spending, cautious sex, and cautious handling of HM/HW. I would offer that it's going to be a time of a declining birth rate for HW and increased responsibility (and liability) for industry . . . and you'll get little for free, except maybe something you don't want. To cop a phrase, we've entered the era of industrial birth control.

With those sobering thoughts as a departure point, I would like to describe the Navy's program in hazardous waste minimization, or HAZMIN. I view HAZMIN as a subset of the broader term, pollution prevention. HAZMIN consists of any actions taken to minimize the disposal of HW. Obviously, the most effective actions are those that eliminate the generation of HW in the first place. Therefore, putting in place a comprehensive HM control and management program is vital and was one of our first and most visible efforts. Before I describe our HM control and management program, let me set the stage by providing a brief history. The Navy actually laid the groundwork for HAZMIN program before the 1984 RCRA amendments requiring HAZMIN. The trends in both HW disposal and liability pointed the way. Before we decided on a strategy for HAZMIN in the Navy, we wanted to ensure that the problem was clearly defined. We also wanted to make better use of our RDT&E resources to solve field problems. Therefore, one of our early actions was to task our Naval Civil Engineering Laboratory to develop an Initiation Decision Report (IDR).

Figure 1 illustrates the IDR concept. This first element of the IDR is a problem definition. This took considerable field work and data analysis. The result is a detailed look at the major Navy processes that generate HW. Most important, we identified 19 processes that generate over 95 percent by volume and over 90 percent by cost of the Navy's HW. This allowed us to narrow our focus, and get the "biggest bang for the buck".

The next element of the IDR was the assessment of current HW minimization technologies applicable to our specific wastestreams. We divided the technologies into four classes:

- T0 Proven technologies in use in the Navy.

- T1 Proven technologies in use in industry, readily adaptable to the Navy.

- T2 Technologies claimed, but needing T&E.

- T3 Technologies (or wastes) needing RDT&E.

Based on the technology assessment, we've taken two actions. First, technologies defined as T0 and T1 are being

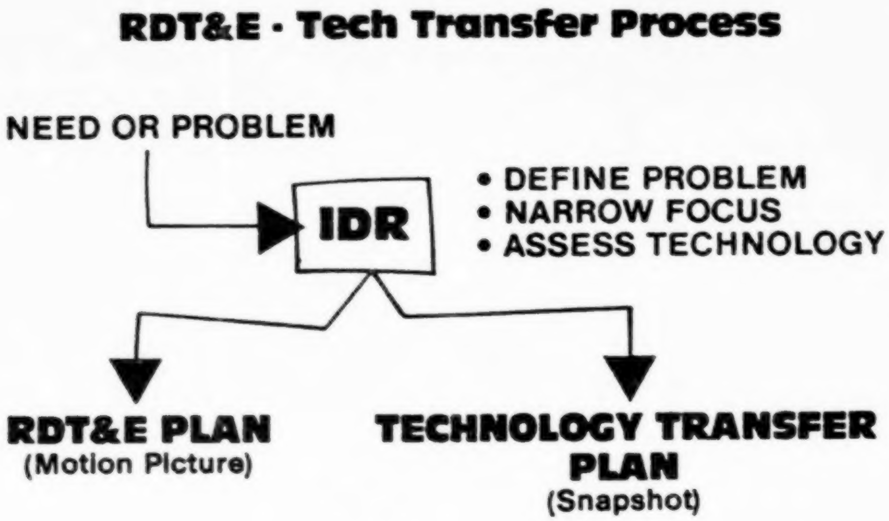

FIGURE 1.

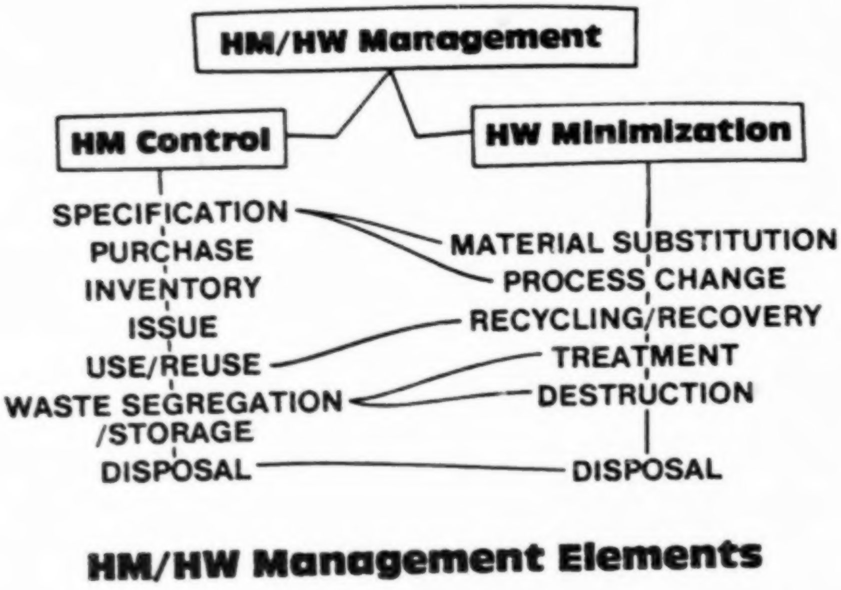

FIGURE 2.

implemented as soon as possible, wherever feasible. We have established a HW minimization technology transfer team specifically to help our field installations use the technologies. The team also serves as a clearinghouse for all HAZMIN efforts in the Navy. Second, technologies T2 and T3 were analyzed to see if RDT&E was warranted. A computer model was developed to aid in this analysis. The decision on whether to spend limited RDT&E resources on a technology is influenced by such factors as risk, capital cost, level of skill to use, percent HW reduction achievable, and whether another government agency is already sponsoring RDT&E on the technology.

Our second step was to set policy and develop an action plan. How do you make HAZMIN happen in an organization as large and as diverse as the Navy? A crucial element is to ensure that all levels of the organization are involved and committed. The following provides the key elements I believe are necessary for success:

- A corporate goal (top-down)
- A strategy and action plan (bottom-up)
- Technology transfer (across)
- Reporting
- Assessment
- Incentives
- Publicity
- Funding

The Navy has a short term and long term corporate goal. Our immediate goal is a 50 percent reduction, by weight, in the amount of HW disposal from 1988 to 1992. Our baseline year is 1987. We based our goal on disposal reduction because we can most easily measure and track HW disposal through an existing reporting system. However, this past year, we changed our reporting procedures to tie each HW back to a generating process. Therefore, we now can track both HW generated and disposed. Our long term goal is tied to our philosophy of Total Quality Management (TQM) in that we want a continual reduction in HW generation as we strive for total elimination of HW disposal. If we have mission needs that necessitate the use of a HM, we want to be sure that we have applied Best Management Practices (BMP) and the Best Available Demonstrated Technologies (BADTs) to each process in order to eliminate or minimize the amount of HW disposed. We've begun development of a BMP/BADT guide for all known process wastestreams in the Navy. This guide will be updated regularly as technologies, procedures, and science evolve.

In 1989, we changed life in the Navy forever by requiring all Navy installations to implement a HM control and management program. The program is patterned, to some degree, after a program pioneered by the Naval Aviation Depot (NAD) in

Pensacola, Florida. Here are some of the key elements of the program:

- Intervening in the acquisition cycle of weapons systems, equipment, and facilities to ensure that HM use is minimized throughout lifecycles.

- Development of facility level authorized HM use lists.

- Systematic review of existing specifications and procedures to eliminate HM use where feasible.

- Implementing overall HM control and management programs, including hazard communications, at Navy installations.

Figure 2 shows how HM control and HAZMIN are interrelated and interdependent. A good HM control program starts with work procedures and product/process specifications that minimize the use of HM. Specifications can often be modified to substitute a nonhazardous material or the process itself can be changed so that HM are no longer used. On the right hand side of the figure, we see that materials substitution and process changes are effective ways of minimizing HW; thus we nave our first connection between HM control and HW minimization. Likewise, control of HM use and reuse is connected to the HW minimization elements of recycling/recovery.

Let's look at some of the major actions underway. One of our biggest problems has been the large amount of hazardous waste offloaded by our ships after extended operations at sea. The Naval Supply Systems Command is attacking this problem in a number of ways. First, a list of approved HM is being developed for each type of ship. This is no small task. Their are over 6000 Naval Stock Numbers (NSNs) for HM. The master HM list will be completed by October, 1990. Eventually, each ship in the fleet will have an individual authorized HM use list which contains the minimum number of HMs needed to accomplish the mission. After June 1991, all open purchase of HM is terminated and any new entries into an approved list after June 1991 must be accompanied by a one-for-one removal. Also, each ship recently has been provided with a CD-ROM player in order to have full access to Material Safety Data Sheet (MSDS) information on each HM authorized. Second, units of issue are being reviewed and reduced to the amounts normally expected to be needed. In other words, you get just enough to do the job, not a stockpile. Third, shelf lives are being adjusted to better reflect reality. Much of the HW offloaded by Navy ships to shore facilities resulted from expired shelf lives. These shelf life estimates were provided in the past by the manufacturer with no checking or adjustment by the Navy. The motto on ship now will be "want not, waste not" or, at least, "no waste before its time".

The elimination of plastics waste disposal by Navy ships at sea is another major effort. We have research underway in a number of parallel efforts: (1) development of a sinkable, biodegradable plastic acceptable to the marine environment, (2) developing standard test methods to determine degradability, (3) developing alternative food packaging technologies instead of plastics, and (4) development of shipboard plastic processing equipment so plastics can be brought back to port for recycling. We already have prototype equipment and have identified processors who can recycle plastic "waste" into useful products.

At our shore facilities, paint stripping operations present one of our biggest problems. Normally, solvents or solvent-based chemicals are applied to aircraft, torpedoes, and other equipment to destroy the paint or its ability to adhere. The paint and solvent mixture are then scraped or washed off with water. An early success stories is the use of a dry plastic media blasting (PMB) technology to replace wet solvent stripping. The plastic media is used in equipment very similar to sand blasting. There are two main differences. The plastic media removes the paint, but does not seem to harm most underlying materials. Second, the media can be collected by a vacuum system or other means and recycled. The process has been approved for use on torpedoes, transportation and construction equipment, and aircraft component parts. Certification for airframes is being withheld pending tests related to "microdents" and material stress. We also have a T&E project underway to determine the loss of media and reduced effectiveness after numerous cycles.

PMB is a good example of a T1 technology. It was developed and was being used by industry. At least one commercial airline company has been using the process. The future may hold even better ways to remove paint. Some of the T2 and T3 technologies being investigated are as follows: (1) laser paint removal using a robot-operated, pulsed CO2 laser; (2) flashlamp paint removal using electromagnetic pulses; and (3) cryogenic paint stripping.

A number of our plating processes for corrosion protection use cyanide as a complexing agent. RDT&E efforts are underway to investigate acceptable noncyanide processes and develop systems for minimizing cadmium cyanide wastes. An electrolytic treatment unit has been under evaluation October 1988 at the NAD in Norfolk, Virginia. Cadmium ions in solution are reduced to elemental metal and recovered in the form of a solid sheet on the cathodic side of the electrodes. The recovered cadmium is returned to the plating bath. Cyanide is oxidized on the anodic side of the electrodes. The unit has operated under field conditions for over 2000 hours without problems or failures. A 99% reduction in cadmium and cyanide was achieved and the wastewater volume was reduced by 90%. A "user data package" is being developed so that this technology can be spread throughout the Navy.

The Naval Ordnance Station in Louisville Kentucky recently adopted an innovative system for chrome plating which reduced chromium discharges more than 85%. The system included installation of a closed loop rinsing system using reverse osmosis, utilization of a new "bright dip formula" containing 75% less chromium than the previous formula, and replacement of the dichromate deoxidizer with a chromium-free deoxidizer. The Naval shipyards conduct hydroblasting to remove scales from the water side of ships' boiler tubes. Field tests have been completed on a system to recycle hydroblast water. Three cycles of use resulted in a 75% reduction in wastewater.

From a Navywide standpoint, can we meet our five year, 50 percent reduction goal? I'm still optimistic, but we are going to face some major "bean counting" problems. In 1989, the Navy increased the amount of solvent recycling by 50% over 1988 and the total HW generation in 1989 is down 7% over 1988. However, gross, unadjusted numbers for HW disposal for our first two years, 1988 and 1989, actually went up slightly as compared to 1987. With so many success stories, how could this happen? We're continuing to analyze the data, but preliminary indications point to a number of factors all working interactively: First, our reporting system is getting much more effective. We're counting better. Second, our employees are much more sensitive about improper disposal. More "small quantity" wastes Navywide are being disposed of through our HW management system vs. down the drain or in the dumpster. In the aggregate, this can be substantial. Third, and most significant, more wastes are being designated as HW and entering our reporting system. As an example, the state of New Jersey began listing bilge water from ships as HW and EPA's new Toxic Characteristic Leaching Procedure (TCLP) adds 25 more organic parameters to the test for HW. The bottom line is this: we're making great progress on a process by process basis, but new sources are popping up. This will require continual adjustment of the FY 87 "baseline" to show progress. It is also a good reason to use the TQM philosophy of continual reduction in HM use and ensuring BMP/BADT are applied to all of our processes rather than just set numerical goals.

QUESTIONS AND ANSWERS

Q. How do the Services go about collaborating to avoid repetition and redundancy? For example, I've seen a couple of things on plating.

A. A number of ways. Within the Navy we have a separate technology transfer team/technology transfer office. Their role is simply to keep in touch with what's going on outside everywhere, to make sure that the technology is transferred within the Navy, and hopefully that we don't duplicate. Also the research laboratories work very very closely together. As an example, if you take a look at chromium plating or cyanide or any of these, you'll find out that each of the Services is doing something a little bit different, and they collaborate. The system that we put in down at Norfolk is a bit different than the system the Air Force is working on. We trade notes, and we find out which one is better. I'm not saying there's no duplication, there certainly is some of that. Some of that's healthy, some of it's not.

Q. Is there a tech transfer office for each Service?

A. Yes there is, and there is a central office that coordinates all research, also. Let me put it this way. Some of the duplication is healthy, and I think we minimize it.

Q. What success are you having in taking an improvement in technology and applying it to similar processes in other plants or other locations? In other words, do you see that it can be easily transferred, or are there design or other barriers to implementation across the board?

A. There are usually unique problems at a location that need to be worked out, and I'll give you a perfect example of that. The Air Force has gone full bore using plastic media blasting. The Navy has gone full bore using it in certain areas - ground support equipment, component parts, torpedoes. We're not using it on airframes. The reason we're not is we have specific concerns that we are trying to work out right now - microdents and stress on the substrate. Secondly, after two or three cycles of plastic media blasting, not only are you blasting with plastic media, you are now blasting with dust and chips and other things from the floor, and we're worried about the effects on expensive aircraft skin, so we're not ready to release it at this point for use.

Q. How long lasting are those beads?

A. That's one of the things that's being looked at. The Air Force actually has a lot more experience than we do. There is some research underway to look at how long they can be recycled.

Q. What kind of program do you have for materials substitution? Is it being done base by base, or is it being done through research and development?

A. It's not being done through research and development. Actually, it's being done in two places. It's being done at what I'll call the grass roots level and at the top level. The grass roots level are the people who carry out the specifications, in weapons systems, for example. They see something in there that calls for hazardous material, and they immediately begin to question it up the chain. At the other end, at our program manager level, at our weapons managers, etc., they are also going through all their entire specifications and procurement documents, to see where they can spec out materials. Not only spec out materials in the actual production of the equipment or weapons system, but spec out hazardous materials in the logistics life cycle, the maintenance cycle, also. We're trying to work it from both ends.

Q. Playing on that, is it manpower intensive, or is there a computer program you can use to search key words, for instance?

A. None that I know of right now. There are some computer applications being used, but it's not as grandiose as one might think it is. It's not uniform. They're individual applications for various weapons procurement managers. There's nothing you can go across the entire Navy and search immediately. It's just not that nifty.

Q. How are you tweaking your baseline? To index things you almost need to look at hazardous waste production against a unit of production, and that's a problem, I think, the generals had. They didn't link that reduction to any index of the base. Are you looking at going back and trying to retrofit unit production into generation?

A. Yes we are. I chaired a joint group recently. Some of the people in this room were on that panel. We looked at producing a hazardous waste index for the logistics community to start, because if you can't do it for the logistics community, who can you do it for? We came up with a little formula for doing it, but the formula requires some individual mission factors for each type of facility. Shipyards are a type of facility. They're going to require a special little mission factor. For example, you take the amount of hazardous waste in pounds they produce, and you divide it by some unit production mission factor that's unique to those people. We think we can come up with an index. We're working that right now. In fact, there's a briefing this month to the Joint Logistics Commanders on the progress with that.

Q. Are you doing that by linking it to personnel hours involved in production lines, or what?

A. The group is looking at the best way to do it, and there are a number of ways to do it. You can look at widgets produced, ships put out of shipyard, direct work hours related to that particular product. There's about ten different ways you can look at it. We're trying to figure which is the best right now.

Q. Are you a contact point for that group? I'm working on the same kind of thing for DOE.

A. Yes. You can contact me.

Q. Just a comment. RCRA is a conservation act, not just a waste measurement act. The real intent with conservation is t measure success by reductions in procurement. If you've actually reduced your chromic acid purchase by 99%, you've mor than met the intent of RCRA. If you have an internal problem where your total waste volume or waste coming out is still the same, that's not a RCRA problem. I think RCRA would be happy to see 99% reduction in natural resource through your procurement reductions

A. Congress and everybody else is asking us "What are your hazardous waste disposal numbers for this year, so we have to track this credibly?"

END

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